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OVERALL MINE CLOSURE AND SITE REMEDIATION PLAN

BRITANNIA MINE
BRITANNIA BEACH, BC

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EXECUTIVE SUMMARY

This document presents the Overall Mine Closure and Site Remediation Plan for the Britannia Mine Site (the Site). This plan will provide the framework for directing current and future mine closure and remediation activities at the Site.

This Plan:

- summarizes environmental issues;
- reviews the governing regulatory framework;
- establishes remediation program objectives, together with development and implementation strategies;
- identifies and summarizes confirmed remedial activities;
- documents the process for selecting remedial components;
- documents the process for prioritising implementation of remedial activities;
- identifies and discusses potential future remedial activities;
- provides a remediation implementation schedule;
- outlines indicators and measures of remedial success; and,
- describes the monitoring and assessment program required to measure remedial success.

Environmental issues pertaining to the Britannia Mine are well documented and have been the subject of many technical studies since its closure in 1974. Major issues are directly attributable to historic mining activity, remaining mine and ore processing waste, metal leaching and acid rock drainage.

This is a very large and complex site, presenting numerous and difficult technical and financial challenges to reclamation and remediation. The mine comprises an area of approximately 4,000 hectares and contains two freshwater watersheds, Britannia Creek and Furry Creek. The size of the mine and its location within the high precipitation west coast climatic zone result in very large volumes of metals-contaminated water flowing from mine workings. This flow affects groundwater, freshwater creeks and the marine environment of Howe Sound.

Successful remediation requires collection of these contaminated waters in mountainous terrain, and access is further complicated by the deteriorated conditions of former mine workings. Successful remediation also requires treatment of considerable volumes of contaminated water characterized by large seasonal flow fluctuations, and systematic enhancement of environments already affected by contaminant discharges.

Site reclamation and remediation is currently directed by the requirements of *Waste Management Act Remediation Order* OE-16907 and the *Mines Act* and *Health, Safety and Reclamation Code for Mines in B.C.* (Code). Risk-based standards have been selected for the remediation process as they enable a phased, iterative approach. Identified environmental risks are successively addressed, with implementation priority based on the risk reduction that can potentially be achieved through a particular action or through the level of protection required for the environment. Effects of remedial actions are then measured and assessed, and depending on the outcome of this assessment, either continued monitoring or additional remedial actions are implemented. This process will continue until remedial objectives are achieved.

The overall objectives established for the reclamation and remediation program are:

Objective 1:

Reduce the discharge of potentially harmful substances, primarily metals, such that habitable areas and aquatic communities within the aquatic environment can naturally recover to acceptable regulatory states. Strategy: Implement the Plan, which includes acid rock drainage (ARD) collection and treatment, and removal or isolation of ARD-generating mine wastes.

Objective 2:

Protect, sustain and promote recovery of aquatic habitat and communities to acceptable regulatory requirements. Strategy: Monitor progress against objective by measuring habitat and aquatic community health, and, where necessary, undertaking additional temporary or permanent remedial actions.

Objective 3:

Achieve and maintain acceptable levels of risk to health and safety for humans and other terrestrial organisms. Strategy: Implement the Plan and meet the mine safety closure requirements.

Objective 4:

Implement remediation in a cost effective and timely manner, such that major environmental risks are reduced or controlled as soon as possible, and long-term viability of the remediation program can be sustained. Strategy: Implement remedial actions that are cost effective and have obvious immediate environmental benefits. Other actions will be implemented if the iterative process of action, monitoring and assessment determines they are necessary.

For a potential remedial action to move forward, it must satisfy both of the following criteria:

Criterion One:

Selection of remediation actions that if implemented, and in comparison to other potential remedial actions, will produce the largest risk reduction to the environment relative to the unit resources expended (risk reduction / cost). This results in a ranking of potential remedial actions, with those of highest rank being implemented first, with implementation continuing with actions of lower rank to the extent of available resources at that time and to the point where criterion two is satisfied.

Criterion Two:

Selection of remedial actions that will achieve or maintain levels of environmental protection identified through risk assessment as necessary for protecting either a specific receptor or a particular population.

The specific performance measures will be developed as part of the environmental monitoring program and risk assessment process.

Three groupings of remedial actions have been compiled. The first grouping consists of remedial actions that have been or shortly will be implemented; the second grouping consists of remedial actions that will be implemented over the next two years; and the third group are potential actions that will be further assessed over the next two years prior to a commitment to implement.

Immediate Actions – Completed or Soon to be Implemented

- construct plug at the 2200 Level portal (by UBC and previous site owner, BMARC);
- removal of concentrate pile adjacent to Mill building;

- removal / stabilization of lower settling pond sediment);
- removal / stabilization of sedimentation pond;
- removal of soils on slopes adjacent to and above Mill building;
- groundwater interception and re-routing to deep outfall in the Britannia Creek alluvial fan area (Fan Area);
- Fan Area storm water interception (south fan) and re-routing to the existing deep outfall;
- surface water diversions around Jane Basin; and
- implement the first stage of an environmental monitoring program and Tier 1 risk assessment.

Committed Actions – Scheduled for Implementation within Two Years

- design and implement mine water collection and storage;
- design and construct mine water treatment plant;
- design and construct new deep water outfall at 50 metres depth;
- plan and implement water treatment plant sludge disposal facility; and,
- implement the second stage of environmental monitoring and a Tier 2 risk assessment, to determine performance measures and prioritise potential remedial actions.

Potential Actions – Decisions within Two Years based on Tier 2 Risk Assessment

- implement additional fan area groundwater interception and treatment (long-term);
- implement additional fan area surface and storm water runoff management, collection and treatment;
- implement additional surface water diversions around Jane Basin and/or Victoria Camp;
- remediate additional mine wastes and portals;
- remediate Fan Area contaminated soils (foreshore, concentrate wharf, museum property, ball park); and
- remediate Fan Area contaminated waste in the inter-tidal zone.

Screening-level human health and ecological risk assessments have been used to identify and characterize potential environmental risk. Over the next two years, a detailed aquatic and terrestrial environmental monitoring program and (Tier 2) risk assessment will be undertaken. These programs will further refine potential risks, and will assist in selecting remedial actions that will result in the largest reduction in environmental risk relative to resources required for implementation. The first (baseline) stage of this program has been completed.

The initial two-year program will include environmental effects monitoring and impact assessment, and will provide information for the development of the long-term monitoring and assessment process. The screening-level risk assessment results indicate human health is not at potential risk from identified contaminants; however, monitoring will be maintained to confirm this position, particularly with respect to potential future changes in land use.

Although the primary focus of this Plan is the environmental remediation of the mine site, mine closure includes a number of additional requirements, some not related to environmental remediation. These are related to public health and safety, as well as industry best practice, as summarized under Section 10.7 of the *Code*.

On September 2, 2003, the Ministry of Sustainable Resource Management (MSRM) acquired ownership of the Site. As required under Section 32 of the *Mines Act*, MSRM, as mine owner, are currently forming an Occupational Health and Safety Committee (OHSC) comprised of the Mine Manager, MSRM staff and other stakeholders, government agency staff and technical consultants as appropriate.

The environmental components of this Plan, together with the recommendations of the OHCS in respect of Section 10.6 of the *Code*, complete the Mine Closure and Reclamation Plan for the Britannia Mine and will form the basis of the closure management manual required by the *Code*.

Treatment of ARD flowing through the mine is a major component of the remediation plan to reduce the adverse environmental impact on Howe Sound. It is critical that a water treatment plant be designed and built to achieve acceptable discharge criteria, and in a manner that ensures the most efficient and cost effective long term operation of the plant. The Ministry of Sustainable Resource Management intends to invite a private sector strategic partner to be responsible for the development of the water treatment plant and who will be able to identify opportunities for cost efficient operation and potential revenues.

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1.0 INTRODUCTION

This document presents the Overall Mine Closure and Remediation Plan (the 'Plan') for the Britannia Mine site ('Britannia' or the 'Site'), on behalf of the Province of BC, represented by the Ministry of Sustainable Resource Management (MSRM).

1.1 Report Objective

The objective of this document is to detail the framework for directing current and future mine closure and remediation activities at Britannia. This Plan summarizes environmental issues, reviews the governing regulatory framework, establishes criteria for selecting remedial components, establishes criteria for prioritizing implementation of remedial activities, identifies and summarizes remedial options, remedial activities confirmed for implementation, identifies and discusses potential future remedial activities, provides a remediation implementation schedule, outlines indicators and measures of remedial success, and describes the monitoring program required to measure the success of remediation methods.

The process described in the Plan is intended to provide sufficient certainty that the proposed remediation, once implemented, will successfully remove, reduce or control identified environmental risks to acceptable federal and provincial requirements.

1.2 Background Information

Britannia Mine is a large copper mine that operated from the early 1900s until 1974. Since its closure in 1974, the mine site has been the subject of numerous environmental studies directed towards understanding and developing methods for reducing or controlling acid rock drainage (ARD) mine water discharge into Howe Sound. A more detailed history of the mine's operating years and of the subsequent environmental studies is presented in the Preliminary Site Investigation and Detailed Site Investigation reports (URS 2002a, 2002b, 2003b) and a number of historical documents referenced therein.

In June, 2001, the government of the Province of BC reached a financial settlement with former mine owners and operators. This enabled the commencement of a program of focused study designed to identify and define environmental issues and to develop and implement appropriate remedial measures. In August 2001, the Province appointed a program project manager (Golder Associates Ltd (Golder)) and subsequently, technical consultants (including AMEC, SRK, URS and Water Management Consultants (WMC)) and initiated a series of integrated studies designed to identify the major environmental issues associated with the mine site and to assess a number of related issues needed for

the evaluation of remedial options, such that remediation planning and implementation could be undertaken. These technical studies comprised:

- Mine hydrology: determining potential storage capacity of the mine for use in conjunction with the water treatment plant, and determining potential water diversion, control and mine in-flow reduction strategies (SRK);
- Water treatment plant feasibility study; determining the appropriate mine water treatment technology and preparation of a feasibility level plant design appropriate to treat the mine discharge (AMEC);
- Flood hazard analysis: determining the nature of flood and debris flow hazard of Britannia Creek and recommending mitigative measures for the Fan Area (WMC);
- Mine water containment: install and monitoring of 2200 level adit plug (Britannia Mines and Reclamation Corporation (University of British Columbia/BMARC)); and,
- PSI's, DSIs, screening level human health and ecological risk assessments, remedial planning for fan and additional areas (URS).

As is typical with evaluating large, complex and potentially high risk to the environment sites such as Britannia, the scientists and engineers involved initially divided the Site by area or by issue, to expedite identification, characterization, and evaluation, and subsequently to development of remedial options for each specific concern. These latest studies have assessed mine workings as well as process, storage, and waste disposal areas across the entire mine site. A reference list of major studies and reports completed for the Province since August, 2001 is presented in Appendix I. These initial studies are now substantially complete, and the next step is to selectively integrate these numerous and complex parts into an overall mine closure and remediation program, followed by remediation implementation upon plan approval.

In addition to technical challenges with respect to the environmental issues identified with the site, investigation and remedial planning has been complicated historically by land ownership and land control issues. As of September 2, 2003, these land issues have been resolved to the extent that remediation planning can proceed with an acceptable degree of certainty regarding land ownership, site access and remediation program control.

The Site is subject to the requirements of a provincial *Waste Management Act* (WMA) remediation order (Remediation Order OE-16907) issued in September, 1999 (and amended in January, 2000) to the former site owner, Copper Beach Estates Limited (CBEL), now Britannia Mines and Reclamation Corporation (BMARC). It is also subject to the closure requirements of a permitted mine under BC's *Mines Act*. The WMA

remediation order, a copy of which is provided in Appendix II, requires that specific site investigations and remedial activities be conducted in a timely manner. Although the Remediation Order does not legally apply to the Province, MSRM intend to address the requirement of the Order and the expectations of the Ministry of Water, Land and Air Protection (MWLAP). Mine closure must also be in accordance with the *Mines Act* and the Health, Safety and Reclamation Code for Mines in B.C (the Code).

2.0 SUMMARY OF THE ENVIRONMENTAL ISSUES

A brief summary of the major environmental issues is provided in the following sections. All of the identified major environmental issues revolve around ARD and metal leaching, and subsequent effects to receiving environments, these being local creeks and the inter-tidal and sub-tidal areas of Howe Sound. Metal contaminants may be directly available to the receiving environments because wastes have been historically deposited in them, or because contaminants have been and continue to be transported through surface and groundwater flows to receiving environment receptors. Identified contaminants of concern are metals, including antimony, arsenic, barium, cadmium, chromium, copper, lead, molybdenum, nickel, selenium silver, tin and zinc. Copper, zinc, and to a lesser extent, cadmium and lead, are identified as the primary contaminants of concern. Specific detail on each of these environmental issues pertaining to the Britannia Mine Site is available in associated documents for which a reference guide is provided in Appendix I. The locations associated with the major environmental issues at the Site are presented on Figures 1-1, 2-1, 2-2 and 2-3.

2.1 Acid Rock Drainage (ARD) and Metal Leaching (ML)

Acid Rock Drainage (ARD) occurs when sulphide bearing rocks are exposed to oxygen and water. This process occurs naturally, however mining activities can promote ARD by increasing the quantity of exposed sulphide minerals and by preferentially channelling water flow through these materials. Naturally occurring bacteria can accelerate ARD by assisting in the breakdown of sulphide minerals.

Acid generation results from the oxidation of pyrite (FeS_2) which is one of the most common sulphide minerals. The dissolved Fe^{2+}, SO_4^{2-} and $2H^+$ represent an increase in the total dissolved solids and acidity of the water. In an oxidising environment much of the ferrous iron (Fe^{2+}) will be further oxidised to ferric iron (Fe^{3+}). At pH values between 2.3 to 3.5, the ferric iron will precipitate as ferric hydroxide, while lowering the pH at the same time.

Elevated metal leaching (ML) is associated with ARD due to the increased metal solubility. Although the sulphuric acid in solution will dissolve some heavy metal carbonate and oxide minerals, it has little effect on heavy metal sulphides. However, any ferric iron left in solution is capable of oxidising and dissolving many heavy metal sulphide minerals, including those of copper, zinc, cadmium and lead. This is the process that accounts for the significant amounts of metals in ARD. It is sometimes important to distinguish between ARD and ML as it is the dissolved metals rather than the acidity itself that is often the primary source of toxicity.

2.2 Mine Drainage Water

The primary source of pollution emanating from the mine site is ARD discharging from mine workings. This large volume flow discharge contains high levels of heavy metals, in particularly copper, zinc and cadmium, followed by aluminum and manganese, and to a lesser extent, lead, resulting in an average metal flux in the order of 300kg/day each of copper and zinc discharging to Howe Sound,. Metal contaminated mine water collects in and discharges from the kilometres of historic underground mine workings into Howe Sound. Work associated with understanding the source, storage, chemistry and transport of the ARD has been the subject of a number of studies, the most recent being the work undertaken by SRK (SRK 2002a,b,c,d,e, 2003b.c,d) The SRK work included a combination of geotechnical, geochemical, hydrological and hydrogeological studies. This ARD mine water discharge into Howe Sound is considered to represent between 85 to 95 percent of the total contaminant discharge from the Site.

2.3 Mine Waste, Surface Water and Groundwater

Sources of metal loading to Howe Sound are present throughout the Site and are associated with disposal areas containing mine waste rock, ore concentrator tailings, or ore concentrate. These wastes have been deposited in core and non-core mining areas, these terms being defined in the *Waste Management Act*. For the purposes of this document, and to conform with adopted site nomenclature prevalent in the cited technical study reports, site issues and plans are grouped by location into the 'Fan Area' and 'Additional Areas' categories as shown on Figures 1-1, 2-1 2-2 and 2-3,. Additional areas are predominately core mining areas; however, the Fan Area has core and non-core areas. Areas with potential sources include: 4100 Portal; 2700 Portal; 2200 Portal; Halfway Town; Mt. Sheer Townsite; Victoria Camp; Beta Camp; Empress Camp; Barbara Camp; 1200 Level Furry Creek Drainage; 1200 Portal Lower Jane Creek; Britannia Creek; additional areas creeks; and inter-tidal areas (Figure 1-1, 2-1 and 2-2).

Additional Areas

'Additional Areas' include the entire mine site excluding those parts of the Britannia Creek fan area (termed 'Fan Area' in the URS reports) used today or in the past for housing, commercial activities, park lands and ore processing. The 'Additional Areas' as referenced in URS reports are substantially a part of the core area.

Aside from the major issue of ARD mine water discharge from the underground workings, the majority of remaining issues in the Additional Areas are related to mine waste rock, sludge, or portal discharge water. Areas of environmental concern are presented on Figure 2-1. Of these, AECs 5, 6, 7, 8, 11, 12, 13, 14, 15 and 22 have been

identified in a screening risk assessment as potentially requiring remediation, with AECs 6, 8, and 12 and 13 being assigned priority for remediation implementation (URS, 2003c).

Although estimates are less certain on relative contaminant transport loadings from Additional Areas waste deposits not captured by transport through former mine workings, URS has estimated that 3 kg/day copper and 4 kg/day zinc discharge to Howe Sound from the Britannia Creek catchment, and that 0.9 kg/day copper and 0.8 kg/day zinc are discharging to Howe Sound from the Furry Creek catchment. Jane Creek, for example, was considered by SRK in 2001 to contribute 5 to 10 % of the metal loading to Britannia Creek.

Fan Area

The Britannia Creek alluvial fan area ('Fan Area') located adjacent to Howe Sound, and particularly the southern half of the fan, was an historical area where mineral processing, handling and storage took place over many decades. Wastes from these activities remain in place and continue to act as sources of metal contamination subject to transport, as do the various other identified waste deposits found throughout the former mining area (Figure 2-3).

Surface water runoff and underlying groundwater flow are the primary transport pathways for contaminants discharging from the Fan area, and from the Site in general. Some historic waste deposition also occurred directly into adjacent creeks and Howe Sound. The contaminant transport loading originating from the Fan area is considered to represent between 5 and 15 percent of the total contaminant water discharge from the mine site. URS have interpreted concentration contours of dissolved copper and zinc in groundwater (Figure 2-4 and Figure 2-5) and have estimated that 10 kg/day copper and 16 kg/day zinc is discharged to Howe Sound from the Fan area.

2.4 Local Creeks

The two main watersheds located within the Britannia mine are Britannia Creek and Furry Creek. Jane Creek and Mineral Creek are major subsidiaries of Britannia Creek. Empress Creek and Portal Creek are subsidiaries of Furry Creek. Historic mining activities were associated with each, and historic workings and mine waste deposits remain along at some portions of each creek. Figure 2-1 shows the locations of these creeks, tributaries, and associated surface mining issues.

These creeks are aquatic receiving environments and Britannia Creek continues to carry metals to Howe Sound in concentrations that potentially adversely affect aquatic life, both in the creeks and in Howe Sound.

2.5 Howe Sound, Inter-tidal and Near-Shore Sub-tidal Area

The inter-tidal zone, extending along and from the fore-shore of the Fan Area has been subject to in-filling with mine rock, tailings, and ore concentrate. In the early years of mining activities at the Site, it is probable that water from the mine workings and the ore concentrator mill was also discharged into this area. Contaminated groundwater and surface runoff water today continues to discharge into this area, much of it passing through metal bearing waste potentially containing metals available for transport.

Aquatic life in the inter-tidal zone of Howe Sound is, to some degree, adversely affected by the waste deposits, and the contaminants transported by surface and groundwater. Assessment is on-going to determine the relative significance of each of the contaminant sources and transport pathways affecting this inter-tidal area. Preliminary results from 2003 studies undertaken by EVS Consultants (report in preparation in September, 2003), indicate that continued adverse affects to aquatic life may be more attributable to continued surface and groundwater contaminant transport than to the historic waste deposits in the inter-tidal zone.

2.6 Howe Sound, Off-Shore Sub-tidal (to 50 metres)

Mine process tailings were deposited into Howe Sound off-shore from the Site during its 70-year operational life. These have been estimated at over 40 million tonnes. ARD water from mine workings was historically, and continues to be discharged off-shore into Howe Sound. Environment Canada has been undertaking studies with the objective of determining the nature and severity of the resultant deposits and their potential affects on the environment (report in preparation in September 2003). Investigation results indicate that the continued discharge of untreated ARD mine water adversely affects aquatic life in Howe Sound. Historic tailings deposits are considered to have had similar effects during the time of deposition; however, the extent of continued affects of these tailings deposited at depth is less certain. Notwithstanding this, treatment of the ARD mine water prior to its discharge to Howe Sound is considered a necessary remediation action for resolving this issue and is the primary focus of remediation order OE-16907 .

3.0 REGULATORY FRAMEWORK

Environmental conditions, including discharges, are regulated by federal and provincial legislation, regulations, policy, procedures and guidelines. These are listed and briefly described below. Descriptions are, in part, derived from the Britannia Additional Areas Remediation Planning Document (URS, 2003c).

3.1 Federal Acts, Regulations, Guidelines and Criteria

Canadian Environmental Protection Act

The Canadian Environmental Protection Act (CEPA) is designed to support sustainable development that is an ecologically efficient use of natural, social and economic resources and acknowledges the need to integrate environmental, economic and social factors in the making of all decisions by government and private entities.

CEPA provides the legislative mandate for the Federal government to establish environmental standards, ecosystem objectives and environmental quality guidelines and codes of practices to be achieved and applied across Canada. CEPA contains a variety of contaminant tracking and reporting mechanisms for toxic substances and adopts the "polluter pays" principle. Specific requirements for waste management permitting are generally left to the provinces to regulate.

Fisheries Act

The Fisheries Act governs commercial and recreational fishing and the protection of fish habitat in all waters (fresh, marine, or estuarine) in Canada. The parts of the Act most applicable to remedial activities relate to the discharge of deleterious substances into fish-bearing waters and to alteration of fish habitat

CCME Guidelines and Criteria

The Canadian Council of Ministers of Environment has developed, and continues to update, numerical chemical concentrations for soil, sediment, surface water and tissue residues in the Canadian Environmental Quality Guidelines (CEQG). These are recommended as levels that should result in negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of ecosystems and the designated resources uses they support.

Environmental use guidelines for water include drinking water, recreational water, aquatic life, irrigation water and livestock water. For soil, environmental land use guidelines include agricultural, residential, parkland, commercial, and industrial. Sediment guidelines include marine and freshwater. CEQG has tissue residue guidelines for wildlife consumers of aquatic biota and air guidelines for human health, vegetation, animals, materials, and aesthetic atmospheric parameters.

The legislative authority for implementation of CEQG lies primarily with each Provincial jurisdiction, with the exception of Federal l .nds. British Columbia has adopted most of the CCME values as its own environmental quality criteria and guidelines.

Metal Mining Liquid Effluent Regulations

The Metal Mining Liquid Effluent Regulations (MMLER) address the discharge of liquid mine wastes to the environment subject to concentration limits for various heavy metals and pH limits. The regulation provides guidance on the nature of control work and environmental monitoring. The MMLER apply to new, expanded and reopened mines.

3.2 Provincial Acts, Regulations, Guidelines and Criteria

Mines Act

In British Columbia, mining is regulated under the Mines Act and the Health, Safety and Reclamation Code for Mines in BC. Mine reclamation activities must be approved under a Section 10 Mines Act permit. Plans for closed mines must be updated every five years, or whenever significant changes occur. Permits issued under Section 10 contain conditions for acid rock drainage and metal leaching prediction and prevention, including conditions for excavation, waste deposition, waste characterization, reclamation, and the provision of financial security for outstanding reclamation liability.

Waste Management Act

The main environmental legislation in British Columbia is the Waste Management Act (WMA), providing a framework for waste disposal, permitting, contaminated sites management, special waste management, municipal waste management, waste ownership and liability and the appeal process.

The WMA and two of its regulations, the Contaminated Sites Regulation (CSR) and the Special Waste Regulation (SWR), provide the legislative framework for assessing, managing and regulating contaminated sites in British Columbia. Authority is also provided to order persons responsible for contaminated sites to investigate and remediate contamination.

Contaminated Sites Regulation (CSR)

The CSR provides assessment and remediation standards (numerical and risk-based) for soil and groundwater, site investigation and remediation requirements, and conditions for obtaining approvals and certificates. The CSR also allows for regulators to adopt protocols and procedures for investigating and remediating contaminated sites.

Sites are considered contaminated sites if applicable numeric soil or water standards are exceeded. Site remediation may use either numeric or risk-based standards. Numeric soil standards for substances are classified into five land use groups and include: agricultural (AL), urban park (PL), residential (RL), commercial (CL), and industrial (IL). Matrix numeric standards, available for some substances, are dependent on available human health and aquatic receptors. Water standards for substances are classified into five water use groups and include: aquatic life (AW), irrigation (IW), livestock watering (LW), drinking water (DW), and no water use (NW). Aquatic life (AW) standards are available for freshwater and marine conditions for most substances.

Risk-based standards, currently only applicable for remediation, employs human health and ecological risk assessment to evaluate potential receptor exposure to contaminants, and determine what remedial activity is required to protect available receptors.

Special Waste Regulation (SWR)

The SWR defines special waste and provides a regulatory framework for controlling its storage, treatment, transportation and disposal. This regulation is applied in conjunction with the Federal Transportation of Dangerous Goods Act (TDG) and the BC CSR. Sites containing special waste are also considered a contaminated site.

Approved and Working Water Quality Guidelines

BCMWLAP has developed approved and working water quality guidelines representative of chemical concentrations not to be exceeded to protect human health (drinking water) and aquatic biota (surface water). Freshwater aquatic life (FAW) and marine aquatic life (MAW) criteria are available.

Draft Criteria for Managing Contaminated Sediment in British Columbia

Draft sediment criteria for sensitive contaminated sites and typical contaminated sites are permissible concentrations in near site sediments if criteria based remediation is used for a site. The sensitive and typical contaminated sites criteria represent conditions considered acceptable and mean that if met, possible biological effects are expected to be relatively absent (sensitive contaminated sites) or minor (typical contaminated sites).

3.3 Application of the Regulatory Process to the Britannia Site

Compliance is required with all the applicable federal and provincial legislation and associated regulations. The site is also currently under a BC *Waste Management Act* remediation order (OE-16097) issued to the former site owner (CBEL, now BMARC). Although the Remediation Order does not legally apply to the Province, MSRM intend to address the requirement of the order and the expectations of MWLAP. This remediation program being conducted by MSRM is systematically addressing each of the ordered requirements, one of the main requirements being the design, construction and operation of a mine ARD water treatment plant. A copy of this order and its requirements are presented in Appendix II.

The mine also remains a permitted mine, albeit under closure conditions, and continues to be regulated under the BC Mines Act, Regulations, and Codes. Federal regulatory requirements also apply simultaneously with BC requirements, particularly with respect to contaminant discharges into receiving water, and to protecting aquatic life and habitat in the local creeks and in the Howe Sound inter-tidal and sub-tidal receiving environments. Generally, meeting the requirements of the BC *Waste Management Act* will also satisfy federal requirements, with the exception of specific permit requirements for specific discharges.

The Overall Mine Closure and Remediation Plan is structured to meet the regulatory requirements and processes of BC's *Waste Management Act* and *Mines Act*, and their associated regulations.

BC's *Waste Management Act* (WMA) and its associated Contaminated Sites Regulation (CSR) require that numerical standards be used to investigate, assess, and delineate the extent of contamination. Remediation however can use either numeric or risk-based standards. Remediation at this site is based on risk-based standards.

Identification, Characterization and Assessment Standards

The Site remains a permitted mine. The predominant land use is therefore industrial (designated 'IL' under the CSR). For the general purposes of investigations directed to identify, characterize and evaluate concentrations of potential contaminant substances in soil, results are compared with the CSR industrial (IL) land use standards. Areas currently under residential land use (RL), commercial land use (CL) or urban park use (PL) are evaluated accordingly. Applicable numeric matrix soil standards are inclusive of standards for the protection of water used by aquatic life.

Surface and groundwater quality are evaluated against CSR marine and freshwater aquatic life (AW) use standards. Surface water bodies, such as Britannia Creek and Howe Sound, are used by aquatic life, and groundwater on the site is generally considered within a 50-year travel time to these receiving water bodies. With the exception of the upper reaches of Mineral Creek and groundwater in the Furry Creek catchment (neither impacted by mining activities) and, during late summer/early fall, Britannia Creek upstream of Tunnel Dam, surface and groundwater is not used as a drinking water source, and is not considered suitable for such use in the future. Therefore, the CSR drinking water standards are not considered applicable to the lower reaches of these creeks or for groundwater. There are also no irrigation or livestock watering uses for surface or groundwater.

Remediation Standards

The remedial approach adopted for the Site, in accordance with the WMA and CSR, uses risk-based standards. This in general means that remediation involves a combination of contaminant source removal, isolation, or reduction, contaminant transport reduction or control, and receptor tolerance or effect evaluation and monitoring. Risk assessment is the foundation for remedial planning and remedial implementation decisions.

The risk-based approach to remediation is frequently referred to as risk assessment and risk management. Often it involves combinations of actions, some of which use numerical standards as remedial end-points for more aggressive interventions, such as selected source removal, and some which use risk assessment to support more passive interventions, such as long-term monitoring. Underlying the risk-based planning approach is Section 28.2 of the Waste Management Act, which addresses the evaluation and selection of remedial alternatives, and requires *"preference to remediation alternatives that provide permanent solutions to the maximum extent practicable"*. Section 28.2 requires the evaluation of costs and potential benefits associated with remedial solutions beyond those required to achieve conditions of acceptable human health and ecological risk. This preference for permanency has been taken into account in developing this remediation strategy.

4.0 OBJECTIVES AND STRATEGY DEVELOPMENT

The mine closure and remediation program for the Site incorporates a staged and phased approach to achieve the highest level of certainty, efficiency, flexibility, and cost effectiveness possible for such a complex and extensive site. This includes the development of an overall site remediation program as presented in this document, and sequentially developing remedial action plans and associated detailed work plans and implementation schedules for identified and approved subsequent remedial tasks. This process is in turn followed by a process of continually refining the plan, as more site information and results of implemented remedial actions becomes available.

Remediation of Britannia Mine poses some unique challenges, not the least being: the magnitude of the major identified problems, the potential number of environmental issues, the potential inter-relationships between issues, and the uncertainty of the relative environmental risk associated with each potential issue. At the same time, although a significant funding source is available, resources are finite, and every effort must be made to achieve the largest reduction of environmental risk for unit effort applied.

This program started in November, 2001, and from the outset there were some obvious first steps, also required under the terms of WMA Remediation Order OE-16907. Site investigations and preliminary human health and ecological risk assessments were a priority, as was a feasibility study for a water treatment plant to collect and treat ARD mine water discharges. Work has also been undertaken to plan and implement other remedial activities, in part selected on a precautionary principle.

From this point forward, with an increased understanding of the Site and its environmental risks, it is necessary to establish clear and unambiguous objectives, criteria and procedures to govern what remedial actions should be included, and when or if potential actions should be implemented. A measuring system is also required to assess remediation success as are procedures that will trigger additional remedial actions where indicated. This process is presented schematically in Figure 4-1. Objectives, procedures and criteria are described in detail in subsequent sections.

The overall objectives of federal and provincial regulations and of this remedial program are to ***protect human health and the environment***. From a strictly regulatory perspective, the overall objective is to satisfy the requirements of applicable Acts, regulations and codes, including BC's Mines Act and the requirements specified in Remediation Order OE-16097. These requirements will be met; however, more specific objectives are also required to govern the day to day process and decisions of the remediation program.

In November 2001 at the beginning of Stage 1 in the remedial process presented above, a two day meeting with stakeholders and regulators in attendance determined the following as the vision or objective of the Britannia Mine Remediation Project:

> "…to develop and implement a project that:
>
> - Will reduce environmental impacts on fisheries (including other aquatic organisms, the fish habitat, and sediment and water quality) resulting from water and sediments originating from the mine site, by meeting site-specific risk-based provincial and federal requirements.
> - Will construct a water treatment plant and other works to treat drainages to meet site-specific provincial and federal requirements.
> - Will reduce contamination-related human health risks on, and emanating from, the mine site by meeting site-specific risk-based provincial requirements.
> - Will consider future sustainable development, compatible with land use designations in SLRD's [Squamish and Lillooet Regional District] official community plan [OCP]."

As the development of the remediation program has progressed, the above overall project vision or objective has been refined into the following four more specific remedial objectives:

Objective 1:

Reduce the discharge of potentially harmful substances, primarily metals, such that habitable areas and aquatic communities within the aquatic environment can naturally recover to acceptable regulatory states. Strategy: Implement the Plan, which includes such actions as acid rock drainage (ARD) collection and treatment, and removal or isolation of ARD-generating mine wastes.

Objective 2:

Protect, sustain and promote recovery of aquatic habitat and communities to acceptable regulatory requirements. Strategy: Monitor progress against objective by measuring habitat and aquatic community health, and, where necessary, undertaking additional temporary or permanent remedial actions.

Objective 3:

Achieve and maintain acceptable levels of risk to health and safety for humans and other terrestrial organisms. Strategy: Implement the Plan and meeting the mine safety [BC MEM Health, Safety and Reclamation Code for Mines in BC] closure requirements.

Objective 4:

Implement remediation in a cost effective and timely manner, such that major environmental risks are reduced or controlled as soon as possible, and long-term viability of the remediation program can be sustained. Strategy: Implement remedial actions that are cost effective and have obvious immediate environmental benefits. Other actions will be implemented if the iterative process of action, monitoring and assessment determines they are necessary.

The remedial priorities and specific performance measures against which the success in meeting the objectives can be measured will be determined during the stage two environmental monitoring and Tier 2 risk assessment process.

4.1 Process to Achieve Remedial Objectives

Risk-based objectives combine a consideration of the specific contaminant substances present at the Site, the affected media, potential exposure pathways and associated risk to human and ecosystem health posed by the Site. The above remediation program objectives, when translated into a remediation process or implementation requirements include:

1. Maintaining at all times current conditions of acceptable human health risk through continued monitoring of potential risks.
2. Identifying and characterizing sources of contaminants and transport pathways, and evaluating and ranking the environmental risks associated with each. (Investigation and characterization of the majority of contaminant sources has been completed. Assessment of transport pathways and receiving environments remains on-going. Initial risk assessment screening has been substantially completed).
3. Identifying immediate remedial actions which could reduce current impacts to the environment during which time longer-term and more permanent remedial solutions are investigated, developed, and implemented. These immediate actions can be based on the precautionary principle rather than on a determination of high relative risk-reduction. They may however also not be permanent or on-going. Subsequent evaluation or subsequent and also related remedial action may demonstrate these

early actions no longer significantly contribute towards the overall remedial solution. (Approved immediate remedial actions are described in a subsequent section).

4. Identifying permanent or long-term remedial actions that will result in the greatest reduction of risk to the environment relative to the resources applied, and relative to other potential risk-reducing actions, and making implementation of these actions a priority.

5. Developing methods to monitor potential future changes in distribution of contaminant substances within soil, surface water or groundwater, and specifying conditions under which additional remedial measures would be needed to further control contaminant migration or aquatic life exposure.

6. Identifying future scenarios (for example, maintenance and/or construction of utilities) that may cause risks to human health and the ecosystem (including to adjacent properties), and provide procedures necessary to control such risks.

7. Defining measures to manage contaminated soil that might be excavated as part of future maintenance and construction activities.

8. Identifying the process that would establish the future need for additional contaminant mass removal, where such measures are shown to be environmentally beneficial, technologically feasible, and cost-effective.

9. Continuing to monitor and evaluate results and effects from each phased remedial action, maintaining flexibility to more aggressively intercede with addition remedial actions where warranted.

10. Recognizing and complying with applicable regulatory orders, permits, standards, objectives and guidelines.

4.2 Criteria for Implementing a Potential Remedial Action

The process of a phased remediation approach using risk-based standards has been described above. One of the critical elements in using this approach is in defining the criteria through which a potential remedial action is screened, ranked and accepted for immediate implementation. For a potential remedial action to move forward, it must satisfy both of the following criteria:

Criterion One

- Selection of remediation actions that if implemented, and in comparison to other potential remedial actions, will produce the largest risk reduction to the environment relative to the unit resources expended (risk reduction / cost). This results in a ranking of potential remedial actions, with those of highest rank being implemented first, with implementation continuing with actions of lower rank to the extent of available resources at that time and to the point where criterion two is satisfied.

Criterion Two

- Selection of remedial actions that will achieve or maintain levels of environmental protection identified through risk assessment as necessary for protecting either a specific receptor or a particular population.

Implicit to the use of the above criteria is a requirement for on-going monitoring of environmental conditions, and scheduled assessments of remedial progress, in terms of meeting program objectives. Monitoring and assessment results ultimately control what potential remedial actions will be implemented, as additional remedial actions will need to be implemented until such time as the remedial objectives are achieved.

4.3 Remediation Feasibility Considerations

Implicit to the above objectives and implementation requirements is recognition that some areas of habitat, whether terrestrial or aquatic, will not be restored to pristine conditions as existed prior to mining operations (even if these conditions were known). Additionally, a risk-based remediation approach (risk assessment and risk management) has been adopted for the Site because applying numerical remediation standards to all environmental issues is not considered feasible. The source contaminants are primarily metals, all of which cannot be removed, or treated *in situ* because of the large waste volumes present or because of the inaccessibility of sources located either in the mine itself, or beneath the town, the Museum and associated infrastructure. Large amounts of the contaminants have previously been discharged into Howe Sound, where they also remain inaccessible, at least in terms of technical and financial capability. Additional information on the feasibility of contaminated site remediation through various technologies is presented in URS 2002e and 2003c.

4.4 Remediation, Monitoring and Assessment Cycle

This remediation program is designed such that immediate remediation actions are identified through either: application of the precautionary principle (i.e., site assessment results indicate that the action should be beneficial to reducing overall environmental risk, and through implementing the action, there is little to no risk of jeopardizing the overall remediation program); or through derivation of a relatively high reduction in environmental risk should the action be implemented (e.g., mine water treatment plant).

Some actions to address potential environmental risks identified by the preliminary risk-assessment are deferred until the affects of linked, immediate actions can be measured and evaluated. (e.g., immediate actions in the Britannia Fan area include collecting contaminated groundwater and storm runoff water and discharging this water through the deep outfall, at least for the near-future. Deferred potential actions in this case include the decision as to whether some or all of this collected water should first be routed through the water treatment plant prior to deep outfall discharge, and whether mine wastes that were historically deposited proximal to or in the adjacent inter-tidal area of Howe Sound should be capped, or selectively removed. The decision as to whether to proceed with these deferred potential actions will depend on monitoring and assessment of the inter-tidal area, and in determining whether the immediate actions have been sufficient to allow habitat and biota recovery).

Immediate and potential remedial actions are presented in a subsequent section titled "Reclamation and Remediation Components" (Section 6).

5.0 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

Risk assessment can have several uses: to determine if a remedial action is required; to identify conceptual remediation options; and to establish risk-based remedial end-points or environmental conditions.

Human health or environmental risk can only exist if: there is a contaminant present at hazardous concentrations; there is a transport pathway present by which the contaminant can move and make contact with a receptor, and there is a receptor (living organism) present that could be affected by exposure to the contaminant.

The risk assessment process requires problem formulation, toxicity and exposure analysis, and risk characterization. Problem formulation identifies contaminants of potential concern, exposure pathways, and potential receptors. Toxicity and exposure analysis examines the particular toxicity characteristics of a contaminant, evaluating how and under what circumstances a contaminant affects particular organisms, and the type of exposure required for harmful effects. Risk characterization evaluates the actual situation at a site, and for a particular contaminant, exposure pathway, and receptor assesses whether existing conditions would in any way be harmful to the receptor(s). Risk characterization can also be used to identify conditions under which the contaminants at a site would no longer pose a risk to receptors.

Screening level human health and ecological risk assessments (Tier 1) have been completed for the Britannia Fan area and Additional Areas (URS,2002c, d, 2003a). An environmental effects and baseline study of the inter-tidal area of Howe Sound adjacent to the Britannia Fan area is approaching substantial completion (EVS, 2003a). Screening level assessments have been used primarily to identify potential problems, and to eliminate areas of potential concern from further evaluation or remedial action. Screening level assessments typically employ a deterministic approach wherein single, conservative and often 'worst case' values are used as inputs to quantitative analysis. If the screening assessment of a potential risk shows that risks meet acceptable regulatory levels, more detailed assessment is not required.

Potential risks that do not pass the screening assessment should either be addressed through a remedial action, or be re-assessed using a more comprehensive and detailed quantitative (Tier 2) risk assessment. The detailed risk assessment frequently uses a probabilistic approach, and more realistic toxicities and exposures that are measured at the site and determined applicable to the specific conditions and receptors at that site. A Tier 2 risk assessment, like a Tier 1, is used to identify potential risks that do or do not require direct remedial intervention. However, a Tier 2 risk assessment is also useful in screening potential remedial solutions, in determining when a particular remedial action should be implemented, and in determining risk-based standards for the site.

Highlights of the screening assessments are presented below. As is noted, immediate remedial actions have been developed based on some of the screening results. Other identified potential risks will be further evaluated using a detailed quantitative (Tier 2) risk assessment, scheduled for implementation in late-2003. The risk assessment and environmental effects monitoring programs are integral to the iterative remedial approach adopted by this plan.

5.1 Human Health Risk Assessment

Human health risks were evaluated for the Fan Area and Additional Areas. The Fan Area is considered the most sensitive in that land use in parts of the fan include urban park, residential and commercial use. The screening level risk assessments used the most sensitive (conservative) potential contaminant exposures and human receptors in the analysis undertaken. Human receptors (and the exposure scenarios) which would be most at risk were determined to be a child trespasser and a construction worker. The risk assessment concluded that contaminants in these areas do not present an unacceptable risk to these receptors of potential concern (construction worker or child trespasser). Therefore, one can conclude that all other human activities on the Site are not subject to unacceptable risk from exposure to the contaminants present (URS, 2002d, 2003a).

5.2 Ecological Risk Assessment

Screening level (Tier 1) ecological risk assessments were conducted for the fan and additional mining areas. (URS, 2002c, 2003a). URS identified that "...there is a potential for adverse effects to some ecological receptors in both terrestrial and aquatic environments on or near the Site".

Additional Areas

Assessment of the Additional Areas to date have identified potential environmental risks at: 4100 Portal; 2700 Portal; 2200 Portal; Halfway Town; Mt. Sheer Town site; Victoria Camp; Beta Camp; Empress Camp; Barbara Camp; 1200 Level Furry Creek Drainage; 1200 Portal; Lower Jane Creek; Britannia Creek; additional areas creeks; and inter-tidal areas. Waste rock is the main contaminated source material. There are also some deposits of sludge and concentrate. Identified AECs are briefly described in Table 5.1 below, and shown on Figures 2-1 and 2-2. Details of the assessment for each AEC are presented in URS Tier 1 Risk Assessments.

Table 5.1: Additional Areas of Environmental Concern

Area I.D.	Environmental Concern
AEC 5 – 4100 Portal Area	Mine waste rock on two slopes (approximately 11,000 m^2 area.
AEC 6 - 2700 Portal Area	Mine waste rock.
AEC 7 – Mt. Sheer Townsite	Sludge – copper launder.
AEC 8 – 2200 Portal Area	Mine waste rock, mine water sludges and copper launder precipitates.
AEC 11 – 1200 Portal below Jane Basin	Mine waste rock.
AEC 12 – Victoria Camp	Mine waste rock.
AEC 13 – Beta Camp (1600 Portal)	Mine waste rock & portal water discharge.
AEC 14 – Furry Creek Portals and Waste Rock Dumps	Mine waste rock.
AEC 15 – Britannia Village Area	Mine waste.
AEC 22 – Halfway Town	Mine waste rock.

URS presented the following as remedial options that could eliminate, reduce or control these identified potential risks.

- Recontouring, soil covers and revegetation of waste dumps on moderate slopes;
- Excavation, consolidation and containment of sludges and precipitates;
- Sealing of portals with significant mine water discharges;
- Diversion of unimpacted surface waters around waste dump areas;
- Disposal of all non-functioning machinery, buildings and scrap related to the historic mining operations;
- Detailed quantitative (Tier 2) risk assessment; and,
- Long-term monitoring and maintenance.

To date, of the ten areas of environmental concern identified by URS using screening risk assessment, priority for consideration of remedial action has been assigned to AEC 8 (2200 Portal Area), AEC 13 (Beta Camp and 1600 Portal), AEC 6 (2700 Portal Area) and AEC 12 (Victoria Camp). The Tier 1 results also confirm that as minimum there is an immediate need to conduct a detailed (Tier 2) risk assessment and a baseline monitoring program of habitat and biota in the creeks. The scope of the work for the environmental monitoring program and detailed (Tier 2) risk assessment is currently under development.

The detailed risk assessment will assist in predicting the potential reductions in environmental risk related to a particular remedial action.

Fan Area

Assessment to date has identified substantial volumes of metals contaminated mine waste in the Fan Area, and in the adjacent Howe Sound inter-tidal area. Environmental risk is attributable directly to these deposits, where they are present in the receiving environment and therefore potentially in direct contact with receptors and through surface and ground water contaminant transport from the land-based deposits. URS presented the following possible remedial options that could eliminate, reduce or control these identified potential risks. These included:

- Capping to reduce contaminant transport availability;
- Removing selected sources;
- Diverting surface water away from contaminant sources;
- Collecting storm water and re-routing its discharge through the deep water discharge outfall, either with or without water treatment;
- Collecting groundwater and re-routing its discharge through the deep water discharge outfall, either with or without water treatment;
- Treating groundwater prior to its discharge into Howe Sound by installing a permeable reactive barrier wall;
- Conducting a Tier 2 risk assessment to better define actual risks, and to establish site-specific risk-based remediation objectives; and,
- In combination with implementing some immediate remedial actions, monitoring effects of leaving some potential risks in place.

At this time, the highest environmental risk reduction potential is associated with collecting and re-routing storm water and groundwater. Some sources have also been selected for removal based on a precautionary principle, primarily because of potential estimated risk-reduction possible relative to expenditure required. Examples include: the concentrate pile, the sludge within the sedimentation pond, and waste rock on slopes adjacent to the mill. These remedial actions are currently in progress. Present and possible future land uses in the Fan Area make the feasibility of any immediate large-scale capping questionable, at least to the extent that further evaluation is required. A Tier 2 risk assessment will be conducted to assess remaining risks and potential improvements following remediate actions selected for immediate implementation.

Howe Sound, Inter-tidal and Near-Shore Sub-tidal Area

The inter-tidal and near shore sub-tidal were included in the URS screening risk assessment, and are also the subject of further environmental effects monitoring and baseline studies currently being conducted by EVS Consultants. The latter is a precursor to a detailed (approximate) two year environmental effects / impact assessment that is scheduled for implementation in late 2003. Results to date indicate that biota and habitat are adversely affected by the continuing contaminated water discharges into this area. It is not yet known what contribution mine wastes historically deposited in the inter-tidal zone continue to have to these effects; however, initial observations support the possibility that the majority of affects are caused by the continued contaminant groundwater and surface water discharges.

Howe Sound, Off-Shore Sub-tidal (to 50 metres)

Environment Canada conducted an environmental effects monitoring program of the deep off-shore sub-tidal zone in and around the locations of the existing and former ARD mine water discharge outfall. Preliminary results indicate that with treatment of the ARD mine water prior to discharge, continued environmental affects will be removed and the biota and habitat of the sub-tidal will recover.

6.0 RECLAMATION AND REMEDIATION COMPONENTS

There are many available remedial strategies to prevent, reduce or control the impacts of ARD/ML. Some mitigation strategies, such as drainage modifications and engineered covers may serve to control and reduce ARD/ML by limiting the movement of water and oxygen into the mine waste. If ARD/ML cannot be prevented or reduced at source then another possible mitigation strategy is to collect and treat the affected water. The "Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" (Price and Errington, 1988) published by the BC Ministry of Energy and Mines (MEM) provides an overview of the main mitigation strategies potentially available for addressing ARD/ML.

As discussed in Section 4, some remedial actions have already been undertaken or are confirmed for implementation. These include a number of immediate remedial actions (under the 'Stage 1 Remedial Action Plan'), particularly within the Fan Area, that will likely have a significant environmental benefit, be relatively straightforward to undertake, and will not compromise longer term remedial actions (Golder, 2003a). These are discussed in Section 6.1.

The remedial actions currently underway also include the design and implementation of the mine water control, and ARD water treatment and controlled water discharge systems. These remedial components are discussed in Sections 6.2, 6.3 and 6.4 respectively.

Studies pertaining to contaminated land are presented in the PSI and DSI reports prepared by URS (URS 2002a,b, 2003b,c). These studies culminated in the preparation of the "Remediation Planning Documents" for the Fan Area and the Additional Areas (URS 2002e, 2003c). These documents contain potential remedial options and actions for each of the AECs identified in previous reports. The next step in the remedial planning and implementation process is to rank each of the AECs, and associated remedial actions, according to the likely environmental risk reduction gained through implementation, normalized against cost. Ranking is generally based on results from a detailed quantitative risk assessment. On occasion, ranking can be based on investigator judgment, knowledge and experience. For expediency, selection of immediate remedial actions at Britannia used this latter approach. Details on the implementation process adopted for this mine closure and remediation plan are presented in section 7.0 below.

The detailed risk assessment that will lead to the ranking of the AECs and associated remedial actions is about to begin. Remedial actions will be proposed for those AECs where there is the greatest associated environmental risk reduction per unit cost. Periodic monitoring will be undertaken to assess if the initial remedial actions have reduced the

observed environmental effects due to ARD/ML to acceptable levels. Should the environmental effects be found to be unacceptable then those actions next in rank will be implemented.

Although it is not possible to confirm at this time which specific remedial actions will be required for some of the AEC's, Section 6.5 describes some of the potential remedial actions proposed in the Remediation Planning Documents. A detailed workplan will be prepared and submitted to the regulators and stakeholders following the decision to implement individual actions based on risk assessment and environmental affects monitoring.

6.1 Immediate Remedial Actions

Given that the site characterization, risk assessment, effects monitoring and long-term remedial planning activities will occur over time, it was decided by the provincial remediation team to identify some immediate remedial actions that will likely have a significant environmental benefit and/or be relatively straightforward to undertake, and will not compromise longer term remedial actions (Golder, 2003). Under a risk-based remediation strategy it is often possible to reduce the overall ecological risk by removing the contaminant source or breaking the contaminant transport pathways that lead to potential receptors.

The ARD mine water discharge has been identified as the major source of contamination. Potential options for interim mine water treatment were examined, however, it was concluded that interim remedies for the mine water treatment were not feasible. The immediate program therefore continues with the design of the mine water management system and ARD water treatment facility as outlined in the following Sections.

Recognizing that interim remedies for the ARD mine water are not feasible, there are a number of other smaller but potentially significant ARD/ML sources and pathways which if remediated will likely result in a measurable degree of risk reduction. Table 6.1 lists and briefly describes the identified ARD/ML sources and pathways identified for immediate remedial action within the Fan Area. The surficial sources listed in Table 6.1 were estimated (URS, 2002b) to contribute approximately 40% of the potential metal loading from the Fan Area to Howe Sound, excluding mine water (preliminary estimates based on screening-level risk assessment results).

Table 6.1: List of Immediate Remedial Actions

Sources or pathways	Proposed immediate remedial action
1. Concentrate Pile	Remove material from museum property and place in temporary storage facility located with sedimentation pond at 4150 level, or transport directly to permanent disposal location in Jane Basin.
2. Sedimentation Pond (at 4150 Level)	Excavate sludge and place in temporary storage facility in the south portion of the pond, or transport directly to permanent disposal location in Jane Basin.
3. Mill Slopes	Remove materials adjacent to the former mill building and place in a temporary storage facility located with sedimentation pond at 4150 level, or transport directly to permanent disposal location in Jane Basin.
4. Lower Sedimentation Pond	BMARC (former site owner) independently excavated these materials and placed them in adjacent concrete bunker and placed a tarp over them to prevent infiltration. Material may subsequently be transported to permanent disposal location in Jane Basin.
5. South Fan Area Groundwater Flow	Install a groundwater pumping well in the area of the south Fan concentrate wharf, and piping to connect with the deep water discharge outfall. Conduct a pumping test to obtain hydrogeological data for permanent remedial design. Continue to operate the recovery well to control groundwater migration to Howe Sound.
6. Fan Area surface Water run-off	Conduct engineering assessment of a surface water interception system along the base of the slope bordering the fan area and if feasible implement the interceptor system.
7. All	Detailed quantitative (Tier 2) ecological risk assessment

The immediate remedial actions proposed for the above sources is excavation and possible relocation to a contained temporary storage facility located within the sedimentation pond at the 4150 Level. The structurally competent southern end of the concrete sedimentation pond will be separated from the undermined northern end by a lock-block barrier, and the containment cell will be graded, shaped and covered with a tarp to minimize infiltration.

Once the access road to Jane Basin has been upgraded (underway in September 2003), the identified source material will be transported for final disposal in Jane Basin. If the access road is completed with adequate time before the onset of winter 2003/2004 then the identified source material may be transported directly to Jane Basin. Material placed in Jane Basin will not be covered. ARD generated by the mine wastes disposed in Jane Basin will enter the mine (along with surface run-off water), where it will be addressed together with other mine water (see Sections 6.2, 6.3 and 6.4).

As well as addressing the presence of surface sources of ARD/ML within the Fan Area, the immediate remedial actions will also begin to address the pathways by which contaminated water reaches Howe Sound. At the time of writing, a pumping well has been installed in the area of the south Fan (concentrate wharf), and a long-term multi-stage pumping test has been completed as part of the evaluation and design of a long-term groundwater capture system. Pumping is currently ongoing at a rate of 100 US gpm and groundwater is being discharged via the existing deep water outfall at a depth of 26m below sea level. These actions will assist in reducing the metal loading via the groundwater pathway to the sensitive inter-tidal habitat in the short-term, while providing additional information to evaluate the feasibility and effectiveness of a long-term groundwater capture system for the Fan Area by numerical modeling and engineering assessment.

Surface drainage collected and discharging from the Fan Area has been identified as another potentially significant contaminant pathway by URS (URS 2002a,b,e). The immediate remedial actions therefore also include the engineering evaluation of how best to install a surface water interceptor system around the Fan Area margin. This evaluation has been conducted and engineering drawings have been completed for construction in the fall of 2003. In the short-term, the collected surface water will be discharged via the existing deep water outfall.

6.2 Mine Water Control, Storage and Collection

Mine water (ARD) and its continuing discharge into Howe Sound is known to represent the largest contaminated metal source of the Site. Possible interim remedial actions that would to some degree reduce continuing environmental effects were evaluated in 2001 and determined not to be feasible. Priority effort was therefore allocated to complete characterization of volumes, mine storage capacity, water quality, and seasonal variations in flow and quality, such that treatment works could be designed and implemented as soon as technically possible.

For clarity, "Mine Water" refers to the water that is collected in mine workings and directed to the adit located on the 4100 Level. This water is the result of precipitation that has entered the mine workings through infiltration of mine shafts, open pits, "Glory Holes" and other openings created by mining operations, and water that infiltrates through natural fractures in the rock. The relatively minor amount of water that is not collected in the mine workings above the 4100 Level either discharges into surface water bodies such as Britannia Creek or Furry Creek, or becomes groundwater that flows through the Fan Area, from which it discharges into Howe Sound.

Each component of investigations, remediation design, and proposed remediation action is detailed below.

Diversion of surface water from entering the mine through the complex of open pits and glory holes to reduce the volume of ARD discharging from the mine is the first component of mine water control. A number of studies conducted by SRK in 2002/2003 (SRK, 2002c,e, 2003c) concluded that around 85% of the discharge from the mine enters through these openings and fractures, however, these studies also confirmed that only limited opportunities exist to divert clean water from entering the mine due to the extensive area, complex geometry, fractured rock, scree slopes and difficult terrain associated with the open pit/glory hole complex. However, two priority diversions have been identified and are being implemented in 2003/4. These are the East Bluff and Upper Jane Creek diversions which comprise water collection structures, pipes and flow monitoring devices. Combined, these diversions are estimated to reduce mine inflows by around 10%. Additional diversion opportunities are still under evaluation by SRK.

The "Storage Facility" consists of the former mine workings between the 4100 Level and the next highest mine entry (3250 Level).. Prior to January 2002, the mine water exited the mine at the 2200 Level and the 4100 Level. A concrete plug installed by BMARC at the 2200 Level in December 2001 now diverts this water back into the mine workings so that it flows to the 4100 Level adit. Obtaining dependable estimates of water storage capacity was critical to determining water treatment requirements.

Therefore, estimates of the available storage volume were made based upon detailed examination of the mine records, and by means of a 'Plug Test' conducted by the Province in 2002 (SRK), details of which are presented in SRK, 2002d and 2003d. The Plug Test utilized an existing concrete plug installed in the 4100 Level to restrict flows out of the mine and allow the mine to fill with water in a controlled manner. The purpose of the Plug Test was to provide a more accurate estimate of available storage capacity in the mine between the adit at the 4100 Level and the 3250 Level, as well providing an understanding of the relationship between storage volume and static head as well as changes in mine water chemistry resulting from the storage.

The results of the Plug Test, combined with a detailed examination of precipitation and climatic records, enabled the provincial remediation team to model the anticipated mine discharge flow rates, such that the desired (optimized) throughput rate for the Water Treatment Plant (WTP) could be derived. Based on this information, it is estimated that the Storage Facility can contain approximately 450,000 m^3 of water up to the 3250 Level. [Note that the Levels are defined in "feet" below the original zero level near the top of Britannia Ridge. The 4100 Level is 850 feet below the 3250 Level.

6.3 ARD Water Treatment

A number of technologies have been considered to treat the ARD, including biological sulphide technology, silica microencapsulation, electrorecovery, onyhydroxide treatment, Low Density Sludge (LDS), High Density Sludge (HDS), and electocoagulation. Assessment of these technologies has included consideration of its industry application, track record, site specific effectiveness, capital and operating costs, review by a technical advisory committee (TAC) and the preferences of the federal and provincial regulatory agencies. As a result of this evaluation process, the HDS technology is considered to be the preferred technology for the treatment of ARD at Britannia. HDS is a neutralization technology that has been demonstrated to be highly effective in removing copper, zinc, and other heavy metals. It produces a chemically stable, free-draining, metal hydroxide precipitate that can be impounded or shipped off-site for disposal or end-use. The chemical stability of the precipitate (referred to hereafter as "sludge") is one of the distinctive features of the HDS process as the metal constituents will not re-dissolve in storage and re-enter the environment.

Other technologies, such as sulphide reduction, show promise and have some potential advantages over HDS (e.g., potentially saleable metal concentrate and a reduced volume or elimination of sludge). However, there are a number of significant issues associated with implementing these technologies, including technical, scheduling and regulatory concerns.

The Ministry of Sustainable Resource Management intends to invite a private sector strategic partner to be responsible for the development of the water treatment plant and who will be able to identify opportunities for cost efficient operation and potential revenues.

Technology Confirmed by Pilot Tests

The suitability of the HDS process for the Britannia mine waters has been demonstrated in pilot plant tests conducted on site in 1997 and 2002. The latter test program confirmed the effluent quality of the earlier test program, provided design parameters, and enabled the Province to test a range of metal concentrations in the influent stream. The projected effluent quality was based on these tests as well as experience at other HDS plants.

Design Capacity Based on Reservoir Modelling

The Plug Test and associated development of a mine reservoir model has provided the basis for determining the Design Capacity of the WTP and the projected quality of the total volume of water treated. The database for the model was derived from 24 years of snow pack data from the nearest watershed, and water flow measurements for this same period (1977 to 2001). The database included 1999, which was considered by SRK to have a "one in fifty year" snow pack. This model is the best available means to predict the volume of water anticipated for capture, however, it has uncertainties as would be associated with any model, and can only be verified through the collection of additional data once the WTP is in operation.

Advantages and Disadvantages of Selected Design

The studies conducted to date provide choices, none of which without infinite resources provide a 100 percent solution to ARD mine water discharges. However, the information available is sufficient to develop an optimal solution for today, balancing technology and cost, predicted efficiency, and predicted reductions in risk to the aquatic environment.

The Province has conducted modeling to assess the percentages of mine water volume that could be treated at various plant sizes, and to assess the frequency of exceeding this capacity. This work was documented in a memorandum from Golder dated December 17, 2002, titled "Model to allow Simulation of Control of Mine Storage Reservoir and Plant Feed Volume". Treatment plant design capacities of 550 m^3/hour, 1,050 m^3/hour and 1,200 m^3/hour were considered with several variations in the hypothetical operating strategy. The study concluded that a plant capacity of 550 m^3/hour would be able to treat about 80% of the available water over the 24-year period used by the model, and capacity of 1,050 to 1,200 m^3/hour would be predicted to treat 93% to 98% respectively. The modeling has demonstrated that even a WTP with a capacity of 3,000 m^3/hour would not be able to handle 100% of the flow, 100% of the time. (The predicted maximum flow rate was over 3,600 m^3/hour during the 1999 spring freshet). A summary of important details of the simulation and feasibility study for the water treatment plant include:

- Historical flow records indicate that in some years there is a second peak period during the autumn wet season.
- The model indicates that the average annual flow rate would be 585 m^3/hour.
- The average freshet period when the WTP would be operating at capacity varies widely from year to year. A period of 10 to 12 weeks is typical. During the remainder of the year there is usually insufficient water to operate the WTP at the design capacity.

- The WTP can be operated at a turndown ratio of up to 4:1. That is, the plant could be operated at as low as 25% of the design capacity.
- When there is insufficient water to operate the plant at 25% of capacity, the mine water can be stored in the reservoir. The sludge bed in the thickener would be re-circulated until there was sufficient water to re-commence treatment.
- The modeling indicates that there would be sufficient capacity in the reservoir, and sufficient correlation between snow pack and inflow volume for an operator to adjust the treatment rate upward in anticipation of a high inflow period. The operator would need to develop a set of decision rules for the operation of the WTP based upon considerations similar to those in the simulation.
- The accuracy of the reservoir model will improve upon by the collection of data once the plant is constructed and operating.
- Further refinement of the model until the plant commences operation is not considered beneficial, in that existing uncertainties are unlikely to be reduced.
- There is a longer-term potential to reduce flow into the mine, through surface water diversions under consideration in the Additional Areas, thereby reducing future peak flow difficulties.
- Contingencies for operation during peak flows are available to alleviate any potential, albeit temporary, affects to the environment.

WTP Effluent Quality

Effluent or ARD mine water discharge quality is, by all studies and evaluations, the most critical consideration of any remedial program for Britannia. The environmental risk represented by currently discharging mine water potentially represents from 85 to 95 percent of the risk represented by present site conditions. As indicated above, it is seldom possible to design and implement treatment such that all possible flow conditions can be mitigated, and as with all engineered solutions, a balanced or optimal solution must be derived that best represents all the conflicting or offset possibilities.

Varying treatment volume flow and treatment input water quality throughout a designated typical year make this a very difficult estimating exercise. With actual and on-going treatment plant operation, variability in estimated average and deviation ranges will rapidly decrease. Projections, and the underlying basis for these projections, are presented below.

- The dissolved metal content of the effluent is determined by pH, which is controlled by the addition of lime to the HDS circuit.

- The total metals content of the effluent is determined primarily by the amount of Total Suspended Solids (TSS) as the solids are primarily metal hydroxide precipitates.
- Toxicity testing of the effluent from the pilot test demonstrates that the effluent passed toxicity tests for [CEMI, 2002a]
- The dissolved metals content of the effluent is not affected by the throughput rate as long as pH is maintained. Therefore, the projected dissolved metals content in the permit application is expected to be met under all operating conditions, including a controlled by-pass event,
- An HDS plant will meet the requirements of the 96-hour rainbow trout LC50 test under all conditions.
- The projected dissolved metal and other pertinent parameter concentrations to be achieved in the effluent under various conditions are documented in the water treatment plant discharge permit application (PE17469).

Also of consideration, in years with average or below average snow pack, the percentage of mine water effectively treated is projected to approach 98 percent of total mine water discharge. However, in years with extreme snow packs, modeling indicates that a treatment plant approximately three times larger than proposed would be required. Such a year was 1999, which is considered to represent a "50-year return period event".

An evaluation was conducted of potential risk reduction gain against the almost exponential cost expenditure required to fully cover these extreme events through construction of a substantially increased capacity treatment plan. Results conclude that the predicted marginal gain, over a very small period of overall treatment time, does not warrant the large additional expenditure.

The proposal, therefore, for a treatment plant design is that during extreme flow periods (frequency of 50 years or greater and for one to months during that year) the plant would only partially treat mine ARD discharge water. This would occur when it is necessary to treat more than 1,050 m^3/hour. However, up to about 1,400 m^3/hour, the mine water would be passed through the WTP and neutralized to precipitate the dissolved metals and WTP effluent would still meet the criteria for dissolved metals, but potentially not meet the criteria for TSS. Modeling indicates that this strategy would enable in the order of 96% of the mine water to be treated. In the event input flow exceeds 1,400 m^3/hour (the Hydraulic Capacity) and the treatment plant flow-through cannot prevent the storage reservoir from overflowing, the excess water would bypass the WTP and be mixed with the treated effluent. Additional lime would be added under this Emergency Discharge condition.

Other details include:

- The projected average annual sludge production rate is approximately 28 m^3/day of dry solids, based on the design flow rate and design metals flux (AMEC, 2002d,f, 2003a).
- Based on the results of the mine reservoir model, the projected average flow of mine water is 585 m^3/hour.

6.4 Controlled Water Discharge Outfall

The WTP Outfall is the piping system that transports the treated effluent from the WTP to the marine environment in Howe Sound. The primary remedial planning consideration is to locate the outfall so that discharges cannot affect habitat and the aquatic community within the inter-tidal zone paralleling Britannia lands, and that the effluent meets the provincial and federal regulatory requirements.

At the design stage, compliance with the ambient criteria is determined by modeling. This model addresses the amount of dilution achieved at various depths of discharge, and can therefore be combined with the projected WTP effluent quality to assess the depth required to achieve ambient criteria.

The model is independent of the location selected for the outfall. Outfall placement however is determined by such factors as geotechnical stability of the offshore slopes and the probability of a seismic event. The modelling has demonstrated that the BC water quality guidelines (WQGs) will be exceeded for several metals on the edge of the initial dilution zone (IDZ), irrespective of the outfall depth (26 m or 50 m). While exceedances at 26 m are considerable and likely to harm aquatic biota, those occurring at 50 m would be expected to result in no adverse environmental effects, particularly if bioavailability is taken into account. Therefore, the outfall is scheduled to be relocated to a depth of approximately 50 metres (Komex, 2002a). At present, a location north of Britannia Creek is under evaluation. The new, deeper outfall is scheduled to be in place by the time the water treatment plant assumes operation.

6.5 Mine Waste, Surface Water and Groundwater

Additional Areas

Part 4.1 of the Waste Management Act defines the Additional Areas ("core area") to include "areas where waste rock and mine tailings are placed, where ground is disturbed by mechanical means, and where there are, or have been roads". The mine wastes within

the Additional Areas have been identified as areas of environmental concern. Viable, cost-effective remedial options for the Additional Areas are limited by the nature and location of the contaminant sources (URS, 2003c). Many of the waste rock dumps are located on steep slopes, with limited or no road access, and are subject to the harsh weather conditions common to the Coast Mountains. Therefore any proposed remedial actions need to be robust and capable of long term performance with minimal amount of maintenance, as is typical of remediation in remote mining locations. The generic remedial actions under consideration (URS, 2003c) include:

- Recontouring, soil covers and revegetation of waste dumps on moderate slopes;
- Excavation, consolidation and containment of sludge and precipitate;
- Sealing of portals with significant mine water discharges;
- Diversion of unimpacted surface waters around waste dumps;
- Disposal of all non-functional machinery, buildings and scrap related to historic mining operations; and,
- Monitoring and maintenance.

Table 6.2 on the following page contains brief descriptions of the potential remedial actions under consideration by the provincial remediation team for each of the AECs in the Additional Areas.

Table 6.2: Potential Remedial Actions in the Additional Areas

Site	Proposed Potential Remedial Actions
Furry Creek Portals and Waste Rock Dumps (AEC 14)	Potential remedial activities are not currently proposed, as these areas are currently inaccessible by road.
Beta Camp/1600 Portal (AEC 13)	Seal Beta Portal – further investigation required. Excavate precipitates from Portal Creek - further investigation required.
Victoria Camp (AEC 12)	Excavate sulphide-rich waste rock from the bank of Furry Creek and dispose on Victoria Camp waste rock dump or in Victoria Shaft. Remove scrap metal. Recontour waste rock dump, cap with soil cover and revegetate. Revegetate the excavated area and remaining waste rock adjacent to Furry Creek.
1200 Portal Below Jane Basin (AEC 11)	No potential remedial action currently proposed due to small size and location with Jane basin.
2200 Portal Area (AEC 8)	Construct a lined containment area at existing sedimentation pond. Excavate sludge from vicinity of historic wooden copper launder and dispose in lined containment area. Excavate the precipitates from the south bank downstream of Jane Creek and dispose in lined containment area. Recontour waste rock dump, cap with soil cover and revegetate. Remove buildings, machinery and metal scrap. Reconstruct Lower Jane Creek through 2200 Level Dump.
Mt Sheer Townsite (AEC 7)	Excavate sludge and dispose in lined containment area at 2200 Level. Backfill the excavated area with local materials. Scarify soil and revegetate the area around the copper launder. Backfill the swimming pool with local material.
2700 Portal Area (AEC 6)	Remove waste rock and mine debris from the edge of Mineral Creek.
4100 Portal Area (AEC 5)	Potential remedial activities not currently proposed, as they may be influenced by design of water treatment plant to be placed at this location.
Britannia Village Area (AEC 15)	Excavate the concentrate material and dispose in lined containment area at 2200 level. Backfill the area with clean fill and revegetate if necessary.
All	Detailed quantitative (Tier 2) ecological risk assessment

Fan Area

The potential remedial actions in the Fan Area were considered in terms of source control or pathway control (URS, 2002e). Table 6.3 contains brief descriptions of the potential remedial actions options under consideration within the Fan Area.

Table 6.3: Potential Remedial Actions in the Fan Area

Potential Remedial Actions	Description
1. "As is" Approach	This requires the acceptance of the current status of the ARD/ML sources and/or pathways "as-is". Although it has been demonstrated that with some land use restrictions this may be acceptable from a human health risk perspective, it would not address the unacceptable ecological risks to the Howe Sound aquatic environment.
2. Capping	Engineered covers can be used to restrict the access of oxygen and water to acid generating mine wastes. Water covers and oxygen-limiting dry/saturated covers have been used elsewhere to reduce sulphide oxidation, but are impractical given the land use in the Fan Area. However, asphalt, synthetic liners, clay covers and shotcrete may all be used to reduce infiltration in different areas of the Fan Area.
3. Source Removal	Source removal will require the excavation of acid generating wastes and transport to a location where environmental impacts are negligible, such as within a lined and capped disposal facility. A potential site-specific solution is to relocate mine wastes to Jane Basin. Leachate from the waste would infiltrate into the mine workings where it would eventually be treated by the water treatment plant. Some source removal is already planned as part of the immediate remedial actions.
4. Surface Water Control	Stormwater collection can be used to divert uncontaminated runoff to drainage systems and thereby reduce direct interaction with surficial mine waste and infiltration to the groundwater pathway where it may come into contact with buried tailings. Some surface water control is already being implemented as part of the immediate remedial actions.

Potential Remedial Actions	Description
5. Groundwater Control	Groundwater control is required if upgradient sources continue to generate ARD/ML impacted groundwater. It has been estimated that up to seven groundwater pumping wells, located across the entire Fan Area would be required to pump at a combined rate of up to about 2,000 m^3/day to capture all impacted groundwater. The contaminated groundwater will need to be either treated, or discharged at a location where there are negligible environmental impacts. 100% groundwater capture will result in seawater intrusion, which may result in reduced well efficiency and an increase in chloride content to an extent that is incompatible with the treatment plant. Consideration may need to be given to separate pumping wells for fresh and saline groundwater, or a barrier wall to prevent saline intrusion in the freshwater pumping wells. Some groundwater control is already being implemented as part of the immediate remedial actions.
6. Low Permeability Barrier Wall	Low permeability barrier walls may be located on the downstream margin of the Fan Area to prevent the flow of saline groundwater towards the pumping wells. Alternatively they may be installed upstream of acid generating sources, such as the tailings within the Concentrate Wharf, to reduce the groundwater flow through the affected ground.
7. Reactive Barrier Wall	A permeable barrier wall is constructed of a porous material that is selected for its ability to change the chemical composition of the groundwater to one that is less toxic to the receiving environment.
8. Combinations of the above	Combinations of barrier walls, flow through reactive barriers, and groundwater control provide the ability to optimize efficiency and cost. One example of under consideration is using a funnel and trap system, in which traditional walls form the funnel, and a flow through reactive barrier constitutes the trap. Groundwater control, through pumping would also be required to maximize the barrier effects of the natural salt water / freshwater interface, and to reduce influx of salt water into zones within which collected or controlled water would require treatment prior to discharge.
9. All	Detailed quantitative (Tier 2) ecological risk assessment.

6.6 Howe Sound, Inter-tidal and Near-Shore Sub-tidal Area

Preliminary, base-line assessments have been substantially completed (URS, 2002a,b,c, 2003a,b,c, EVS, 2003a). An approximate two year monitoring program and environmental impact assessment is scheduled for implementation in the fall, 2003. This work will encompass the inter-tidal, as well as the immediate near-shore sub-tidal areas. The purpose of these studies is to determine relative benefits of collecting contaminated groundwater and storm runoff and discharging this water through the deep outfall. Results will also influence whether additional remedial actions in the fan area are required to meet remedial objectives.

6.7 Howe Sound, Deep Off-Shore Sub-tidal

Environment Canada has recently completed an assessment of environmental conditions in the off-shore sub-tidal (report under preparation in September, 2003). This assessment will be used as a base-line for future assessments and in determining the amount of environmental risk-reduction realized in treating ARD mine water prior to discharge through the deep out-fall. A re-assessment is proposed for one year after the waste water treatment plant is in operation.

As a part of immediate remedial actions, the deep-water outfall currently discharging at 26 metres depth will be re-located to discharge at 50 metres depth. This action is being implemented as a precautionary measure, providing additional certainty that a treatment plant upset will have minimal effect on the sub-tidal. Additionally, the deeper discharge point provides the potential of continuing to divert fan area storm water runoff from the more sensitive inter-tidal areas immediately adjacent to the Fan Area to the sub-tidal below the photic zone.

6.8 Mine Safety

Although the primary focus of this Plan is the environmental remediation of the mine site, Mine Closure includes a number of additional requirements, some not related to environmental remediation. These are related to public Health and Safety, as well as industry best practice as summarized under Section 10.7 of the Code.

6.8.1 Safety Assessments

As part of the Mining and Hydrogeology study supporting the Plan, SRK prepared a report titled mine safety inspection reports (SRK, 2001a, 2003a). The objective of that report was to provide a preliminary assessment of the (then) current safety condition of the various mine workings and associated mine infrastructure. The report provides

background information necessary to identify and prioritize the final rehabilitation of the mine workings and infrastructure across the Site. The assessment undertaken by SRK included the following:

- 4100 Level portal and adit, 4100 Level Wye and ore chutes, 4100/4150 Level ore passes, 4150 sub-Level and sedimentation pond at the 4150 Level;
- Openings entering the mine from the Britannia Creek watershed at 3250, 3100, 2700, 2700 Armour, 2200, 1200, and 1000 Levels;
- Mineral Creek (timber) culvert;
- Jane Basin Glory Holes and Open Pits, including Jane, East Bluff, Fairview;
- Victoria Camp area, including Victoria Shaft, Victoria Glory Holes, 1200, 1600 (Beta), 1800 and 1900 Levels;
- Openings entering the mine from the Furry Creek watershed at the 500 (Barbara), 600, 700, 850 and 1050 Levels and Empress Glory Hole.

In addition, the report assessed surface and underground hazards associated with the mine at the time of the inspection.

As part of the environmental remedial planning works at the mine, additional assessments have been undertaken by MSRM consultants on the following:

- The stability of a large rock mass located west of Jane Basin ('Jane Block');
- Coarse ore bins (above 4100 Level Wye);
- 3250 Level, 4100 Level, and 4100 Level Wye;
- Geotechnical stability assessment of the sedimentation pond at the 4150 Level; and
- Mill service tunnel (Museum attraction) raises.

6.8.2 Occupational Health and Safety Committee

On September 2, 2003, the government (MSRM) acquired ownership of the Site. As required under Section 32 of the Mines Act, MSRM, as mine owner, are currently forming an Occupational Health and Safety Committee (OHSC) comprised of the Mine Manager, MSRM staff and other stakeholders, government agency staff and technical consultants as appropriate.

One of the tasks of the OHSC, once formed, will be to review the SRK mine inspection and safety reports (SRK, 2001a, 2003a). , together with other safety-related assessments and determine the need for measures to satisfy Section 10.6 of the Code, in particular, sub-sections 10.6.5 (Securing of Openings) and 10.6.6 (Major Dumps). Once identified, MSRM will provide recommendations for appropriate remedial actions at the mine to satisfy Code requirements. The OHSC will be formed during October, 2003 and the review undertaken by March 1, 2004.

The environmental components of this Plan, together with the recommendations of the OHCS in respect of Section 10.6 of the Code, complete the Mine Closure and Reclamation Plan for the Britannia Mine and will form the basis of the closure management manual required under sub-section 10.6.12 of the Code. Section 10.7 of the Code (Reclamation Standards) will be adhered to in the Plan wherever feasible and where not feasible, a Variance will be sought by MSRM under Section 1.2 of the Code.

6.8.3 Anticipated Mine Rehabilitation Works

Stage 1 rehabilitation works were undertaken in the 4100 Level adit and Portal in late 2001 and early 2002 in preparation for the mine filling test ('Plug Test'), comprising a limited program of scaling, rock bolting and meshing of the adit walls and roof in selected areas.

Rehabilitation works anticipated to be required as part of the long-term environmental remediation of the mine site (Stage 2 rehabilitation) currently include a higher standard of stabilization of the 4100 Level Portal and 4100 Level adit, together with works at the 4100 Level Wye 3250 Level portal, 4150 Level Portal, and Mill service tunnel raises. The OHSC review will identify any additional rehabilitation or safety-related work associated with other areas of the mine that are required to comply with the Code.

7.0 IMPLEMENTATION OF REMEDIATION PLAN

7.1 Process

This document thus far has presented and described the main parts of the remediation plan as outlined on Figure 4.1. These included summarizing environmental issues, detailing the applicable regulatory framework, presenting remediation objectives, defining criteria for implementing remedial activities, and describing the proposed and potential remedial actions. This section describes the process through which the remediation plan will be implemented.

Implementation is designed as an iterative process. Initial priorities have focused on completing investigations that allow definition of the major environmental issues, and activities to allow collection and treatment of the ARD mine water. These priority activities are requirements stipulated under Remediation Order OE-16097 and those identified through screening risk assessments.

From this juncture forward, and for the next two years, items listed as immediate remediation actions will continue to be implemented simultaneously with Tier 2 Risk Assessment work to identify potential next step remedial actions. The purpose of the detailed quantitative (Tier 2) risk assessment is to establish risk based standards for the protection of the local creeks and Howe Sound. Many areas of environmental concern have been identified in early assessment work. The intent now is to identify which require future intervention. Once immediate remedial actions have been implemented, environmental effects monitoring will be used to identify environmental change. For each receiving environment, for example, Britannia Creek, the effects monitoring / environmental impact assessment can potentially show no change, deterioration, or improvement to the environment.

Improvement will be used to support the status quo with continued environmental monitoring. No change and especially deterioration will result in a re-evaluation of remedial actions taken, and a review of other potential alternative actions. Potential remedial actions will then be assessed against the criteria presented in section 4.0 above, and provided sufficient certainty of risk-reduction or receptor protection can be demonstrated, the potential action will be forwarded for remedial implementation. A detailed remediation work plan would then be developed for the remedial action, providing a summary of the environmental issue it is intended to address, justification for its implementation, alternatives considered, detailed implementation methodology and an implementation schedule. This work plan would then be submitted to regulators and other stakeholders for approval prior to implementation. Approved work plans will be considered addendums to this Mine Closure and Remediation Plan.

The implementation process outlined above is presented schematically in Figure 7-1. The following provide additional guidance on how this iterative process works.

1. Investigations are used to identify and characterize areas that do not meet generic numeric standards. This step eliminates some issues, and moves forward others for further evaluation of potential risk to the environment (or human health).

2. Some issues, such as the need to treat mine water discharge, are assigned a high implementation priority without further formal evaluation and are assigned resources for developing and implementing a remedial solution. Typically, the need for remedial action is not disputed, the cost of implementation is less than that of additional evaluation, or the cost of additional evaluation exceeds the potential benefit through immediate implementation.

3. Identified potential issues (potential risks) are screened using a Tier 1 risk assessment. This step again can eliminate some issues. The remaining issues have a potential; however, relative to each other, the risk is as yet indeterminate. Like step 2 above, some issues such as the need to intercept and re-direct groundwater flow from the Howe Sound inter-tidal, may be assigned a high implementation priority without further formal evaluation.

4. Identified potential risks are next subject to a detailed quantitative (Tier 2) risk assessment, which is intended to establish site-specific remediation standards or end-points, to provide the basis for selecting a potential remedial solution and to establish the priority in which remediation of an issue should be implemented.

5. The next step is to prioritize potential remediation actions in accordance with the objectives described in Section 4.

6. Remediation work plans are then developed for the higher priority issues, and implemented. Appendix III presents a roadmap of documentation associated with the remediation planning and implementation process. An example of a remediation work plan is presented in Appendix IV.

7. Environmental effects monitoring is then undertaken, followed by an assessment of remedial success.

8. Some issues will meet the established risk-based remedial end-points and mine closure requirements, and for these, the process ends. For those that do not, the cycle is repeated beginning at step 4 above, until the risk-based standards are achieved. Some issues and risks will require long-term monitoring and maintenance solely to maintain mine safety requirements.

7.2 Consultation

A consultation process with federal and provincial regulators, land owners, adjacent land owners, and the immediate community of Britannia Creek was established early in this remediation development process. This process is described in (AMEC, 2001a). It is intended that this process be continued for all proposed activities.

7.3 Schedule

An outline remediation implementation schedule is presented in Figure 7-2. The detailed master project schedule on which this is based is being reviewed and updated on a monthly basis.

8.0 ENVIRONMENTAL EFFECTS MONITORING AND IMPACT ASSESSMENT

Environmental effects monitoring and associated environmental impact assessments are critical to the success of this mine closure and remediation plan. These are the techniques used to measure success or failure, and ultimately control the extent of remediation at Britannia. There have been numerous monitoring assignments at Britannia; however, requirements have never been formally assessed nor collated into a long-term sustainable program. Program details are currently being formulated. Requirements for the next two years are scheduled to be finalized and implemented in October 2003 following detailed consultation with regulatory authorities. A long-term monitoring and assessment program will be developed based on the results of work conducted during the next two years.

8.1 Existing Monitoring Programs

The current water monitoring program is presented in Golder, 2003b. This program includes collecting and analyzing water collected from the Britannia and Furry Creek watersheds, groundwater and storm water from the fan area, and mine water discharging through the deep water outfall. Initial baseline biota and habitat surveys have been conducted by URS, EVS, and Environment Canada (Appendix I).

8.2 Monitoring Program Requirements

There is an immediate need to review, refine, re-establish and maintain water quality and flow quantity monitoring programs for surface water runoff, local creeks, mine water discharges, storm sewer discharges, groundwater, and inter-tidal and sub-tidal water. In addition to physical measurements, biota and habitat need to be evaluated and routinely monitored in all receiving waters. Assessment is required of which receptors naturally inhabit streams in the Britannia and Furry Creek watersheds. Biological surveys on affected streams in the Additional Areas are required to determine assimilative capacity of the receiving environments. Work conducted by URS and more recently by EVS Consultants forms the base-line for future work.

Additionally, the level of risk to human health must continue to be monitored, particularly where land use changes are proposed. Terrestrial risk like-wise must be monitored, particularly with respect to risks associated with former mine workings.

8.3 Environmental Effects Monitoring and Impact Assessment

Initial Two Year Monitoring and Assessment Program

The initial two year program is planned as a comprehensive monitoring and assessment program, including all environmental components of the Britannia mine. Monitoring will be established to compliment existing base-line data, and provide the data necessary to conduct ***a detailed aquatic and terrestrial risk assessment***. Establishing the characteristics of potential contaminant transport pathways, and related risk to potential receptors will be a priority. The environmental effects monitoring program for aquatic environs will include fisheries and benthic invertebrate community surveys and associated tissue analysis, effluent and sediment toxicity testing, selection of sentinel species, and establishing reference sites. Results from this initial monitoring and assessment program will ultimately be used to refine and direct the overall mine reclamation and remediation program. A detailed quantitative (Tier 2) ecological and terrestrial risk assessment will also be completed during this period.

Ongoing Monitoring and Assessment Program

One of the deliverables from the initial two year monitoring and assessment program will be developing an on-going monitoring program. It is anticipated that this program will include routine, scheduled monitoring combined with less frequent environmental assessments. Human health and terrestrial risk monitoring, and the sub-tidal would be included in this program.

8.4 Reporting

The results of all site remediation activities including inspections, pump-and-treat system performance, monitoring and environmental assessments at the Site will be summarized in a Monitoring and Maintenance Report, which will be issued on an annual basis. The report should include the results of all chemical testing conducted during the year and an interpretation of the data. The report will also provide recommendations, if any, for revisions to the monitoring and maintenance schedules, and the need to invoke contingency actions, if warranted, to ensure that the remedial plan objectives are met.

Reporting will also be conducted on the monitoring and maintenance of mine workings, engineered structures, portals, portal plugs, sludge disposal, dams, and flood management.

9.0 REMEDIATION BUDGETING SUMMARY

Table 9.1 presents a high level summary of estimated future costs associated with this mine closure and remediation plan. The estimated costs are subject to review on an ongoing basis.

Table 9.1: Summary of Present and Estimated Future Remediation Costs

CAPITAL COST	2003 Dollars
Remedial Components:	
WTP construction	$13,190,000
WTP sludge landfill land purchase (provisional)	$500,000
Contaminated Sites Remediation - Fan Area	$1,964,000
GW collection/treatment South Fan	$254,000
Phase 2 4100/4150 mine rehab	$200,000
Jane Basin Surface Water Diversions	$200,000
Phase 1 Rehab other Mine Workings	$300,000
Contaminated Sites Remediation - Additional Areas	$2,000,000
Remedial Components - Sub Total	**$18,608,000**
Additional Upfront Costs (Technical Studies and Project Management) – Subtotal	**$6,349,000**
CAPITAL SUBTOTAL	**$24,957,000**

ANNUAL OPERATING COSTS	
Annual WTP operation (incl. service and landfill)	$1,297,500
Annual contaminated sites works operation (incl. monitoring)	$225,000
OPERATION & MAINTENANCE SUBTOTAL	**$1,522,500**

ANNUAL CAPITAL REPLACEMENT COST	
Annual capital replacement (starting in year 26 of operation)	$619,000
CAPITAL REPLACEMENT SUBTOTAL	**$619,000**

10.0 PROFESSIONAL STATEMENT

In order to fulfill the requirements of Section 63 of the *Contaminated Sites Regulation*, the following statement is made:

"Pursuant to Section 63 of BC's Contaminated Sites Regulations Golder Associates Ltd. confirm that this plan has been prepared in accordance with all applicable requirements of the Waste Management Act and of the Contaminated Sites Regulation".

"Pursuant to Section 63 of BC's Contaminated Sites Regulation, Golder Associates Ltd., certify that Gerry O'Hara, Robert McLenehan and Graham Bradley have demonstrable experience in the assessment and remediation of contaminated soil, sediment and groundwater and are familiar with environmental issues associated with the site as applicable to this Plan."

GOLDER ASSOCIATES LTD.

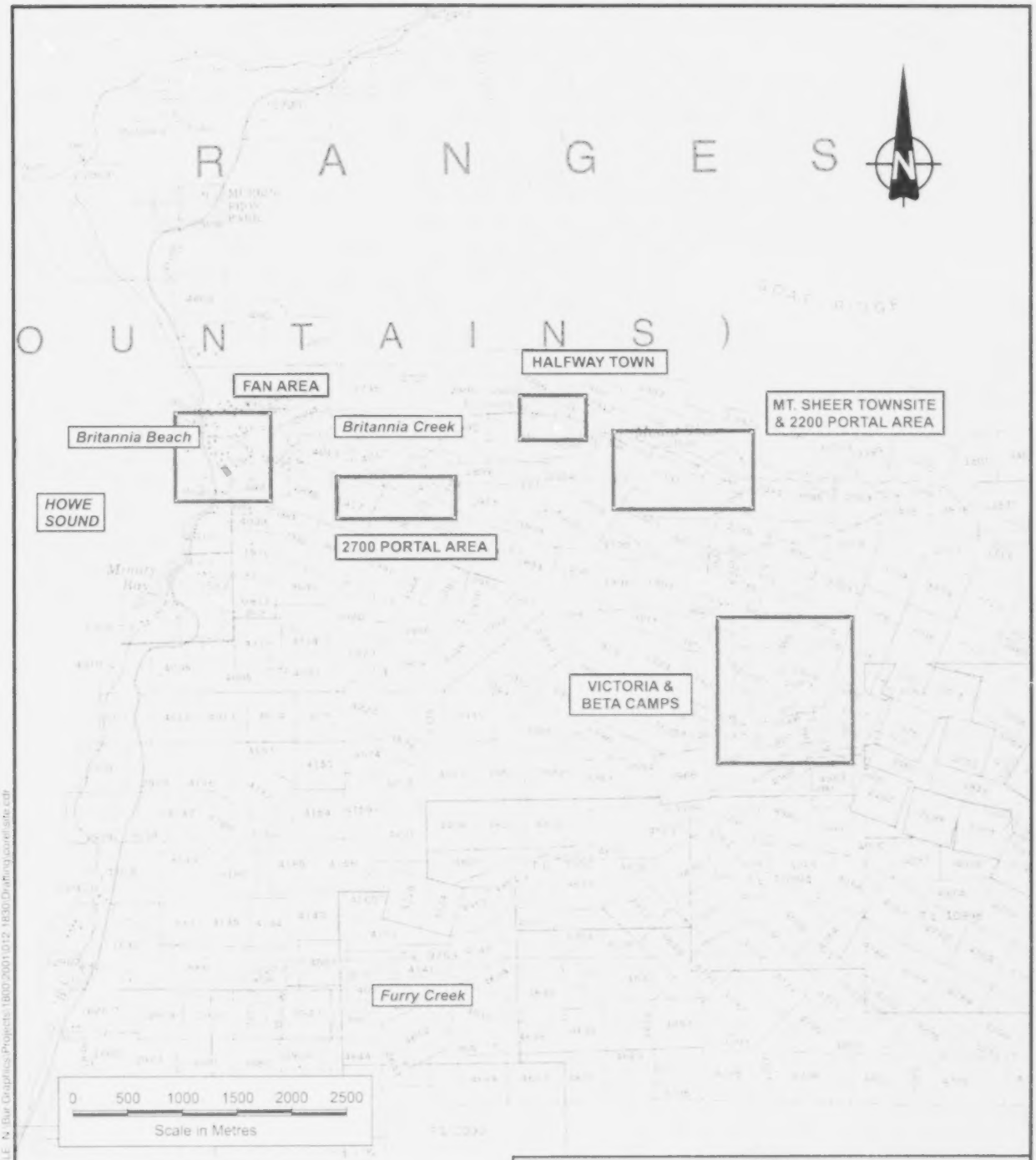
Gerry O'Hara, M. Phil., P.Eng.
Principal, Britannia Mine Remediation Project Manager

R. McLenehan, P.Eng.
Associate

G. Bradley, C.Geol. (UK)
Senior Hydrogeologist

GOH/REM/GB/rja
012-1830
N:\Final\1800\2001\012-1830\REPORTS\Overall Mine Closure October 8, 2003 - FINAL\Rep 1008 Overall Mine Closure and Site Remdiation Plan.doc

FIGURES



LEGEND

Study area

REFERENCE

1) "General Site Locations, Additional Areas, Preliminary Site Investigation (URS, June 2003).

URS

PROJECT: MSRM REMEDIATION BRITANNIA

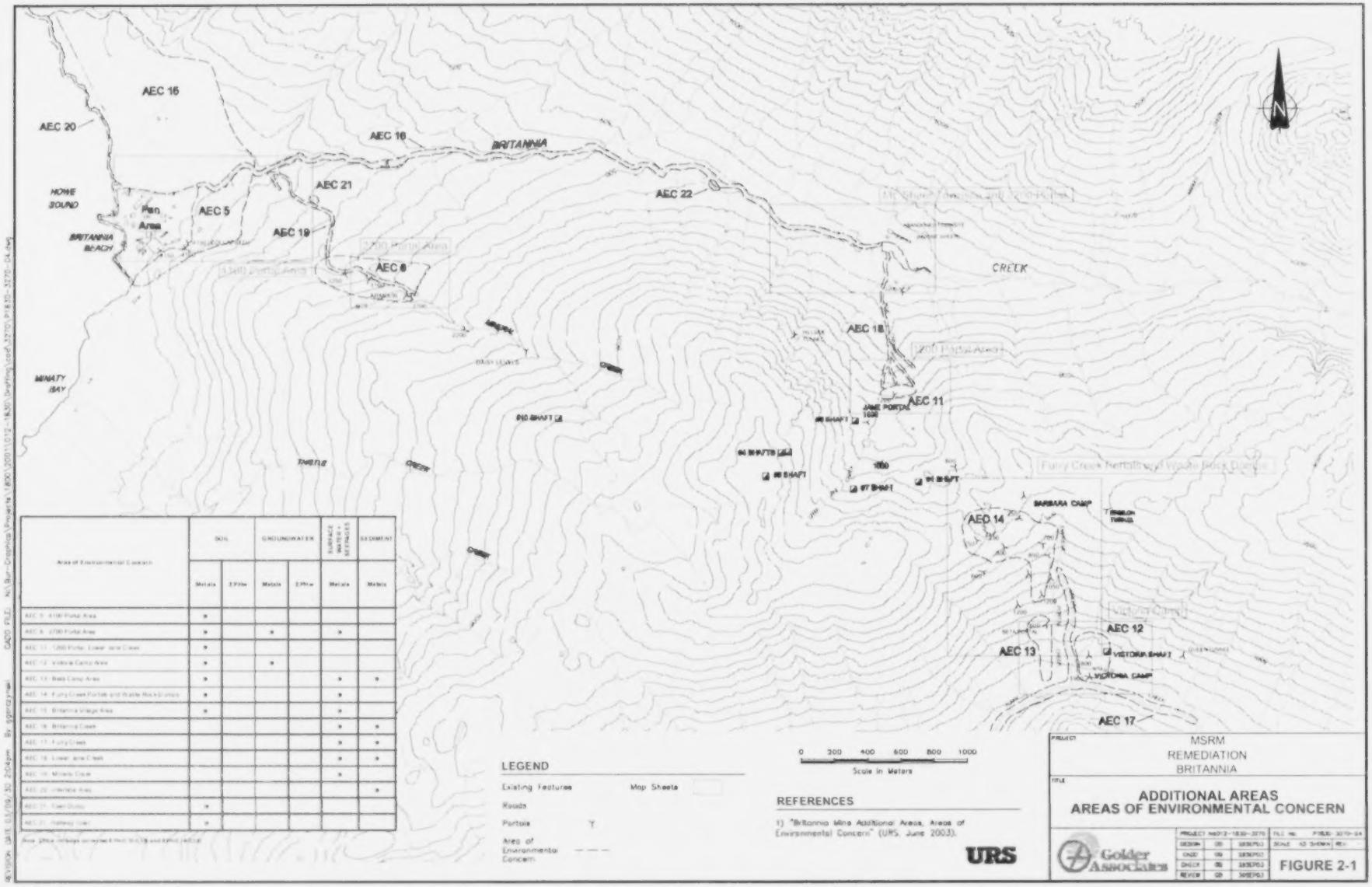
TITLE: SITE LOCATIONS

Golder Associates

PROJECT No. 012-1930-3270			FILE No. site	
DESIGN	GB	29SEP03	SCALE NTS	REV.
CADD	GG	29SEP03		
CHECK	GB	29SEP03		
REVIEW	GB	30SEP03		

FIGURE 1-1

REVISION DATE: 29SEP03 BY: GG COREL FILE N:\Bur Graphics\Projects\1800\2001\012-1830\Drafting\corel\site.cdr



Areas of Environmental Concern	SOIL		GROUNDWATER		SURFACE WATER + SEEPAGES	SEDIMENT
	Metals	2,3,7,8-TCDD	Metals	2,3,7,8-TCDD	Metals	Metals
AEC 5 - 4100 Portal Area	•					
AEC 6 - 2700 Portal Area	•		•		•	
AEC 11 - 1200 Portal, Lower Jane Creek	•					
AEC 12 - Victoria Camp Area	•		•			
AEC 13 - Base Camp Area	•				•	•
AEC 14 - Furry Creek Portals and Waste Rock Dumps	•				•	
AEC 15 - Britannia Village Area	•				•	
AEC 16 - Britannia Creek					•	•
AEC 17 - Furry Creek					•	•
AEC 18 - Lower Jane Creek					•	•
AEC 19 - Minaty Creek					•	
AEC 22 - Victoria Area						•
AEC 21 - Twin Creek	•					
AEC 20 - Halfway Creek	•					

Area Office Villages surveyed (Check in GCS and APEC Table)

LEGEND

Existing Features — Map Sheets

Roads

Portals

Area of Environmental Concern

REFERENCES

1) "Britannia Mine Additional Areas, Areas of Environmental Concern" (URS, June 2003).

URS

PROJECT: MSRM REMEDIATION BRITANNIA

TITLE: ADDITIONAL AREAS AREAS OF ENVIRONMENTAL CONCERN

Golder Associates

PROJECT NO: 013-1830-3270 | FILE No.: 13830-3270-04

DESIGN: GD | 28SEP03 | SCALE: AS SHOWN | REV:

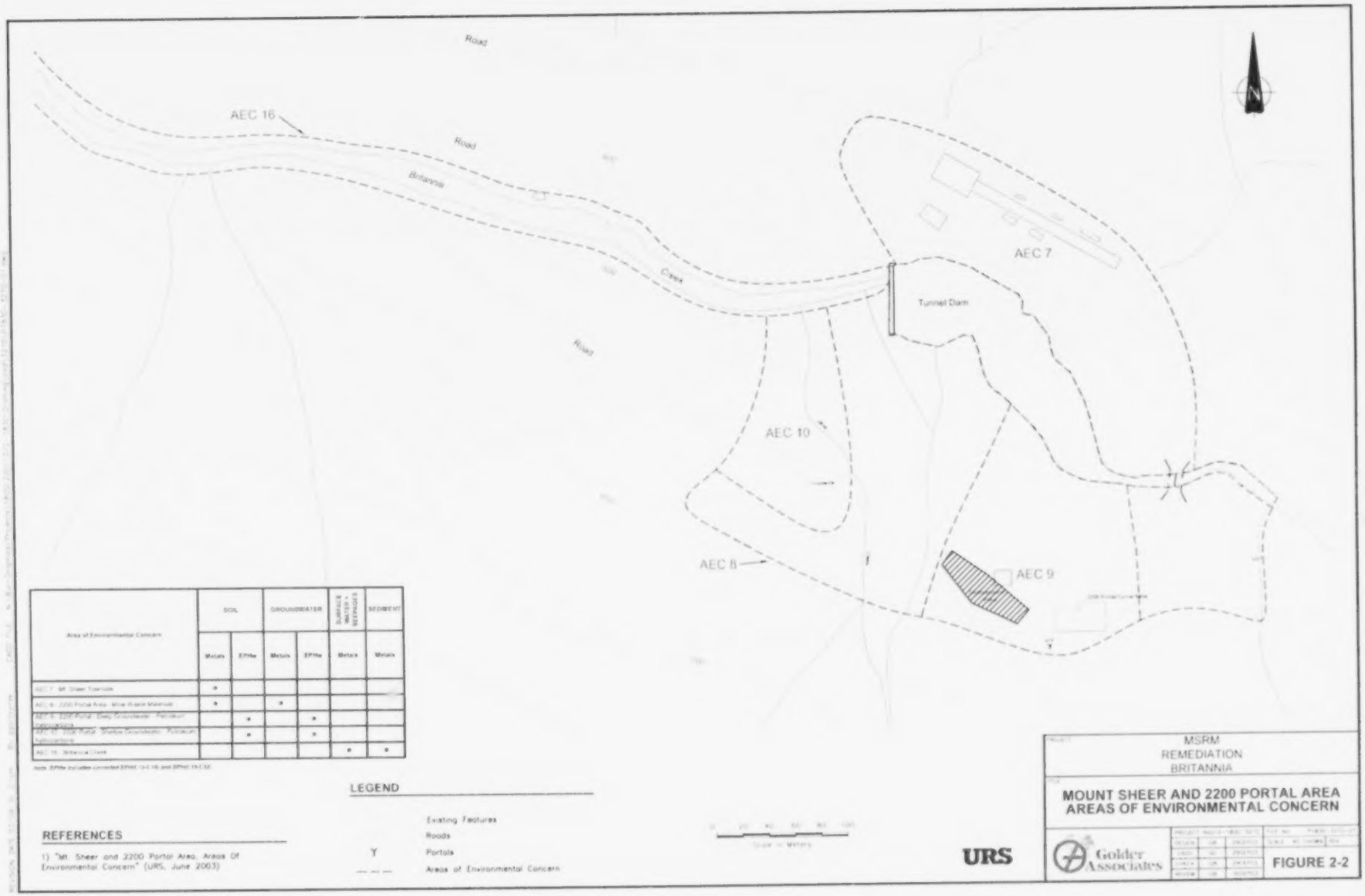
CADD: GD | 28SEP03

CHECK: GD | 28SEP03

REVIEW: GD | 30SEP03

FIGURE 2-1

REVISION DATE: 01/09/30 2004pm By: sgonzalez CADD FILE: N:\Bur Graphics Projects\1830\2001\013 - MSRM Drafting\Cad\13770_FIG 2-1_3770-04.dwg



Area of Environmental Concern	SOIL		GROUNDWATER		SURFACE WATER + SEEPAGES	SEDIMENT
	Metals	EPHw	Metals	EPHw	Metals	Metals
AEC 7 - Mt. Sheer Townsite	o					
AEC 8 - 2200 Portal Area - Mine Waste Materials	o		o			
AEC 9 - 2200 Portal - Deep Groundwater - Petroleum Hydrocarbons		o		o		
AEC 10 - 2200 Portal - Shallow Groundwater - Petroleum Hydrocarbons		o		o		
AEC 16 - Britannia Creek					o	o

note: EPHw includes corrected EPHC 10-C19, and EPHC 19-C32

REFERENCES

1) "Mt. Sheer and 2200 Portal Area, Areas Of Environmental Concern" (URS, June 2003)

LEGEND

Existing Features
Roads
Y Portals
Areas of Environmental Concern

0 20 40 60 80 100
Scale in Meters

URS

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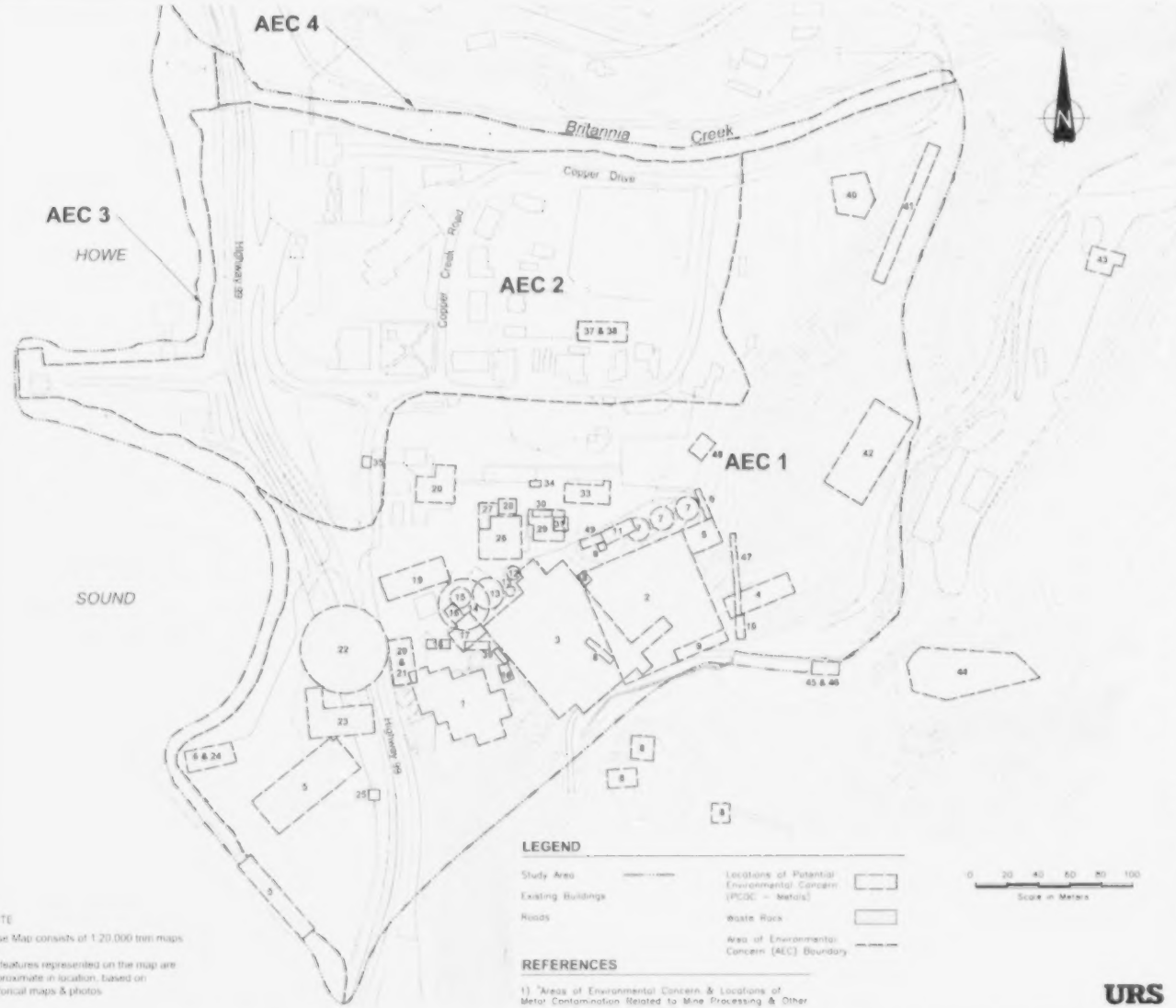
BRITANNIA

MOUNT SHEER AND 2200 PORTAL AREA
AREAS OF ENVIRONMENTAL CONCERN

Golder Associates

FIGURE 2-2



FAN AREA

LOCATION	STATUS	PCOCs
1 No. 1 Mill	Historical	Metals
2 No. 2 Mill	Historical	Metals
3 No. 3 Mill	Existing	Metals
4 Powerhouse	Existing	Metals
5 Concentrate Storage	Historical	Metals
6 Reagent Plant/Precipitate Storage	Historical	Metals
7 Zinc Tanks	Historical	Metals
8 Transformers/Substations	Historical	Metals
9 Ore Bins	Historical	Metals
10 Compressor Plant	Historical	Metals
11 Foundry	Historical	Metals
12 Lime Storage Tank	Existing	Metals
13 Settling Tank	Historical	Metals
14 No. 4 Settling Tank	Historical	Metals
15 Thickener Tank	Historical	Metals
16 Copper Sulphate Plants	Existing	Metals
17 Lead Plant	Existing	Metals
18 Regrinding Mill	Historical	Metals
19 Settling Pond	Existing	Metals
20 Garage	Existing	Metals
21 Precision Shed/Garage	Existing	Metals
22 Pyrite Storage	Historical	Metals
23 Boilers/Steam Compressors	Historical	Metals
24 Precipitate Storage	Historical	Metals
25 Concrete Warehouse	Historical	Metals
26 Machine Shop	Existing	Metals
27 Blacksmith Shop	Existing	Metals
28 Motor Shed	Existing	Metals
29 Welding Shop and Cutting Shed	Existing	Metals
30 Friction Saw Shed	Historical	Metals
31 Rod Shed Shop	Historical	Metals
33 Warehouse	Existing	Metals
34 Coal Storage	Historical	Metals
35 Incinerator	Historical	Metals
36 Ball Mill	Historical	Metals
39 Foreman Machines	Historical	Metals
40 Settling Pond	Existing	Metals
41 Copper Launder	Existing	Metals
42 Sedimentation Pond	Existing	Metals
47 Oil Storage Tunnel	Historical	Metals
48 Carpenter Shed/Shop	Historical	Metals
49 Drug Plant	Historical	Metals
55 Stormwater	Existing	Metals

ADDITIONAL AREAS

LOCATION	STATUS	PCOCs
8 Transformers/Substations	Historical	Metals
42 Car (rail) Shop	Historical	Metals
44 Dock Pile	Historical	Metals
45 Steel Shop	Historical	Metals
46 4100 Car Barn	Historical	Metals
54 Unauthorized Dump (not shown)	Existing	Metals

LEGEND

- Study Area
- Existing Buildings
- Roads
- Locations of Potential Environmental Concern (PCOC – Metals)
- Waste Rock
- Area of Environmental Concern (AEC) Boundary

0 20 40 60 80 100
Scale in Meters

NOTE
Base Map consists of 1:20,000 trim maps

All features represented on the map are approximate in location, based on historical maps & photos

REFERENCES

1) "Areas of Environmental Concern & Locations of Metal Contamination Related to Mine Processing & Other Activities" (URS, October 2002)

URS

PROJECT
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BRITANNIA

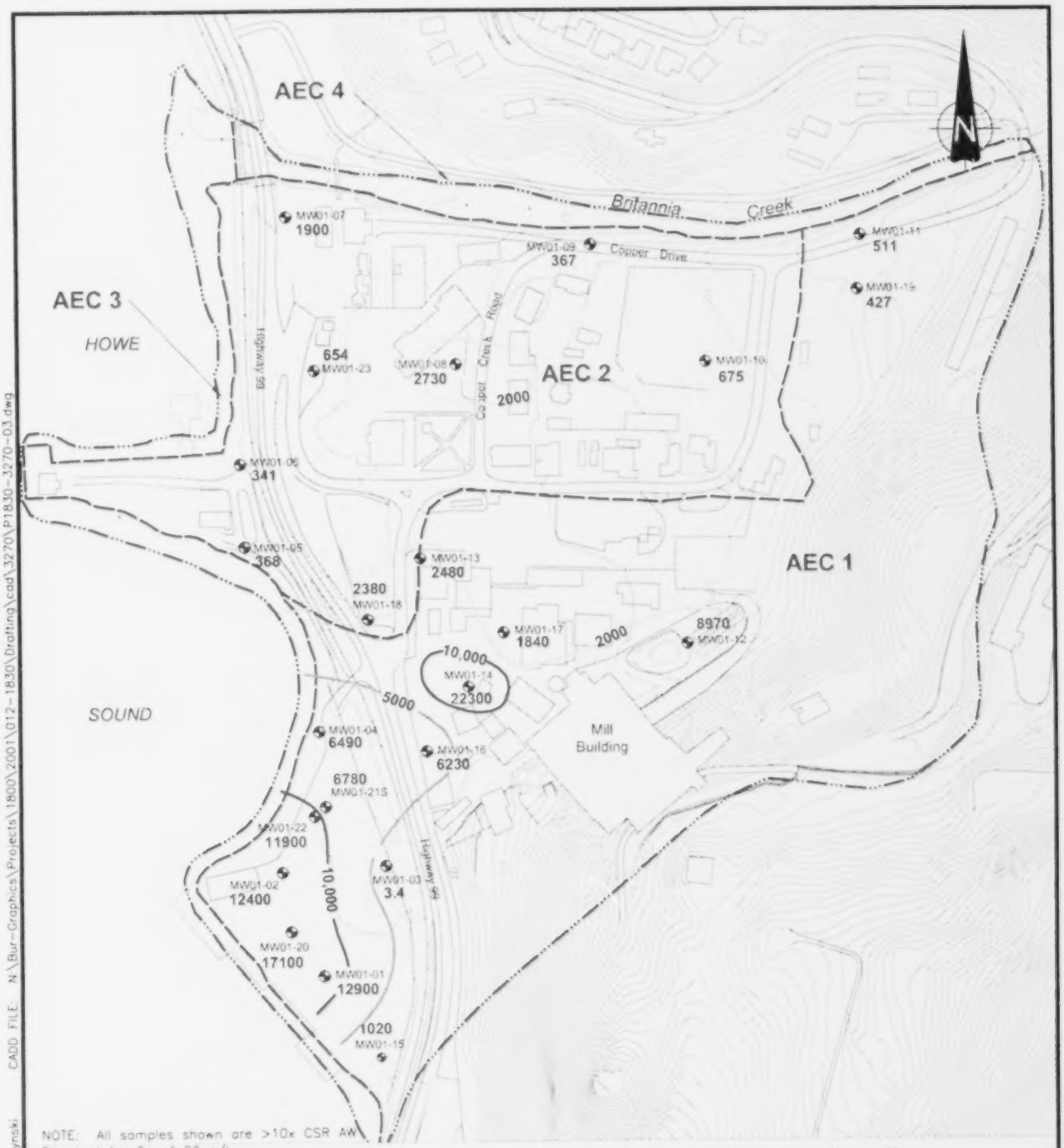
TITLE
FAN AREA
AREAS OF ENVIRONMENTAL CONCERN AND LOCATION OF HISTORIC ACTIVITIES

Golder Associates

PROJECT No.	1-1830-3270	FILE No.	1830-3270-05
DESIGN	GB	28SEP03	SCALE AS SHOWN REV.
CADD	GL	28SEP03	
CHECK	GB	28SEP03	
REVIEW	GB	30SEP03	

FIGURE 2-3

REVISION DATE: 03/08/06 J:\Jobs\... By: apperryman CADD File: N:\Burnaby\Projects\1830\2003\3012-1830\Drafting\cad\3270-P1830-3270-05.dwg



NOTE: All samples shown are >10x CSR AW Standard for Cu of 20µg/L

LEGEND

Study Area		Monitoring Well Location	
Existing Buildings		Copper Concentration (µg/L)	6230
Roads		2000 µg/L (100xAW)	
Sediment Ponds		5000 µg/L (250xAW)	
AEC Boundary		10,000 µg/L (500xAW)	

REFERENCES

1) "Dissolved Copper Concentrations in Groundwater" (URS, October 2002)

URS

PROJECT: MSRM REMEDIATION BRITANNIA

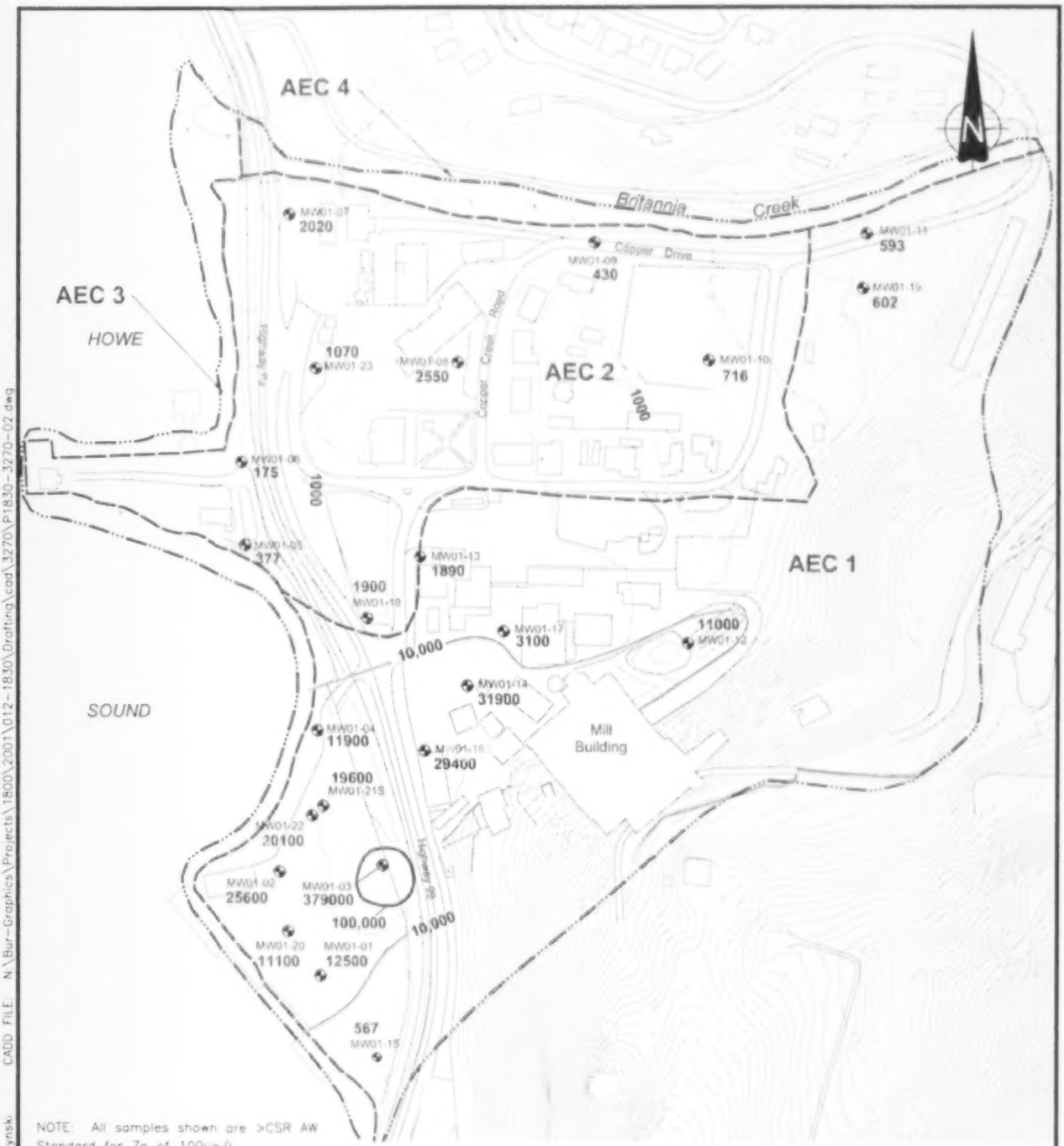
TITLE: **FAN AREA DISSOLVED COPPER CONCENTRATIONS IN GROUNDWATER**

Golder Associates

PROJECT No. 03-1830-3270			FILE No. P1830-3270-03	
DESIGN	GB	29SEP03	SCALE AS SHOWN	REV -
CADD	GG	29SEP03		
CHECK	GB	29SEP03		
REVIEW	GB	30SEP03		

FIGURE 2-4

REVISION DATE: 03/09/30 2:09pm By: gjarczynski CADD FILE: N:\Bur-Graphics\Projects\1800\2001\012-1830\Drafting\cad\3270\P1830-3270-03.dwg



NOTE: All samples shown are >CSR AW Standard for Zn of 100µg/L

LEGEND

Study Area		Monitoring Well Location	
Existing Buildings		Zinc Concentration (µg/L)	567
Roads		1000 µg/L (10xAW)	
Sediment Ponds		10,000 µg/L (100xAW)	
AEC Boundary		100,000 µg/L (1000xAW)	

REFERENCES

1) "Dissolved Zinc Concentrations in Groundwater" (URS, October 2002)

URS

PROJECT
MSRM
REMEDIATION
BRITANNIA

TITLE
FAN AREA
DISSOLVED ZINC CONCENTRATIONS IN GROUNDWATER

Golder Associates

PROJECT No. 03-1830-3270			FILE No. P1830-3270-02	
DESIGN	GB	29SEP03	SCALE AS SHOWN	REV -
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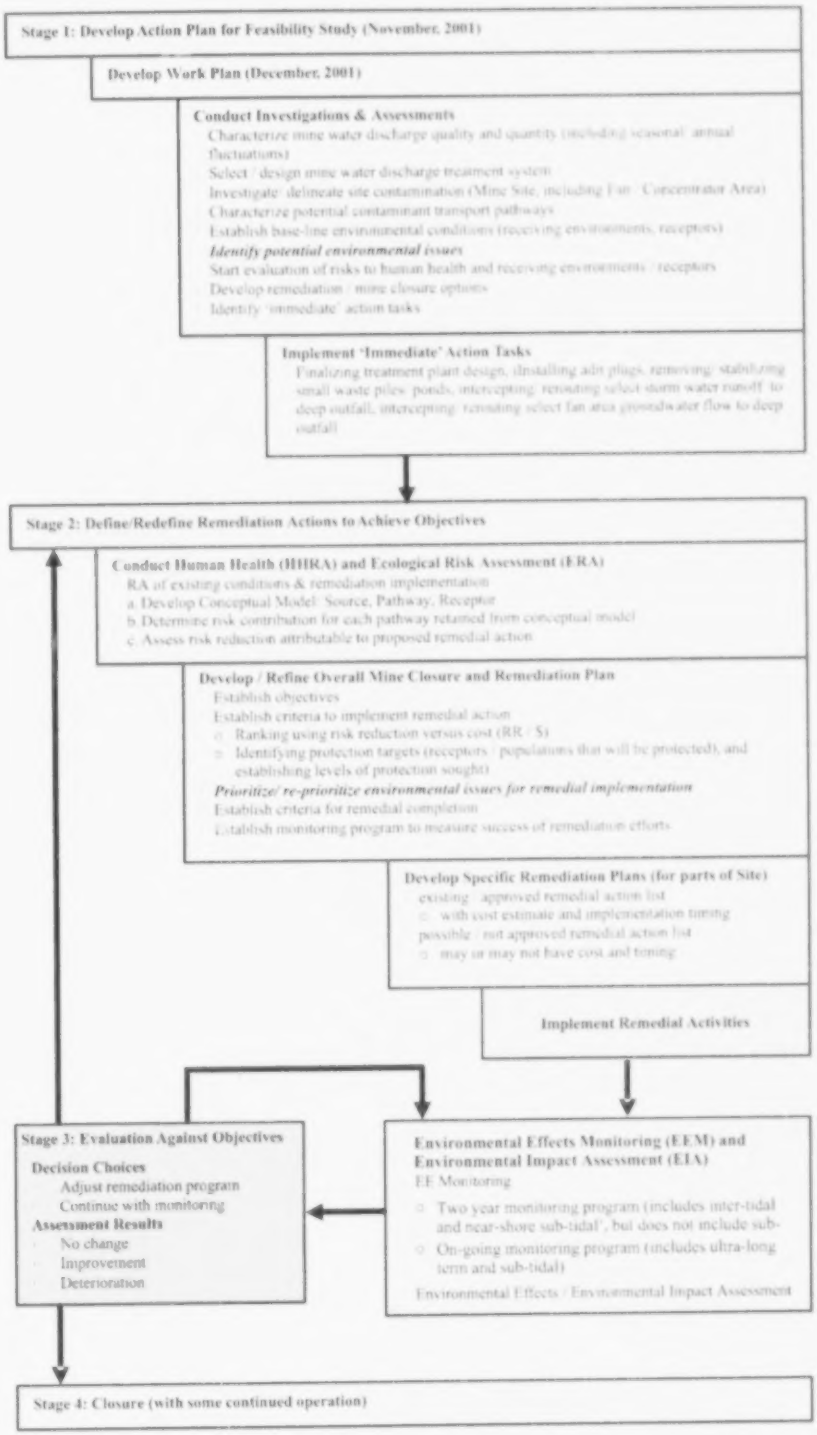
CHECK	GB	29SEP03		
REVIEW	GB	30SEP03		

FIGURE 2-5

REVISION DATE: 03/09/30 2:14pm By: ggorczynski CADD FILE: N:\Bur-Graphics\Projects\1800\2001\012-1830\Drafting\cad\3270\P1830-3270-02.dwg


Stage 1: Develop Action Plan for Feasibility Study (November, 2001)
Develop Work Plan (December, 2001)
Conduct Investigations & Assessments
Characterize mine water discharge quality and quantity (including seasonal / annual fluctuations)
Select / design mine water discharge treatment system
Investigate/ delineate site contamination (Mine Site, including Fan / Concentrator Area)
Characterize potential contaminant transport pathways
Establish base-line environmental conditions (receiving environments, receptors)
Identify potential environmental issues
Start evaluation of risks to human health and receiving environments / receptors
Develop remediation / mine closure options
Identify 'immediate' action tasks
Implement 'Immediate' Action Tasks
Finalizing treatment plant design, installing adit plugs, removing/ stabilizing small waste piles/ ponds, intercepting/ rerouting select storm water runoff to deep outfall, intercepting/ rerouting select fan area groundwater flow to deep outfall
Stage 2: Define/Redefine Remediation Actions to Achieve Objectives
Conduct Human Health (HHRA) and Ecological Risk Assessment (ERA)
RA of existing conditions & remediation implementation
a. Develop Conceptual Model: Source, Pathway, Receptor
b. Determine risk contribution for each pathway retained from conceptual model
c. Assess risk reduction attributable to proposed remedial action
Develop / Refine Overall Mine Closure and Remediation Plan
Establish objectives
Establish criteria to implement remedial action
Ranking using risk reduction versus cost (RR / $)
Identifying protection targets (receptors / populations that will be protected), and establishing levels of protection sought)
Prioritize/ re-prioritize environmental issues for remedial implementation
Establish criteria for remedial completion
Establish monitoring program to measure success of remediation efforts
Develop Specific Remediation Plans (for parts of Site)
existing / approved remedial action list
with cost estimate and implementation timing
possible / not approved remedial action list
may or may not have cost and timing
Implement Remedial Activities
Stage 3: Evaluation Against Objectives
Decision Choices
Adjust remediation program
Continue with monitoring
Assessment Results
No change
Improvement
Deterioration
Environmental Effects Monitoring (EEM) and Environmental Impact Assessment (EIA)
EE Monitoring
Two year monitoring program (includes inter-tidal and near-shore sub-tidal', but does not include sub-
On-going monitoring program (includes ultra-long term and sub-tidal)
Environmental Effects / Environmental Impact Assessment
Stage 4: Closure (with some continued operation)

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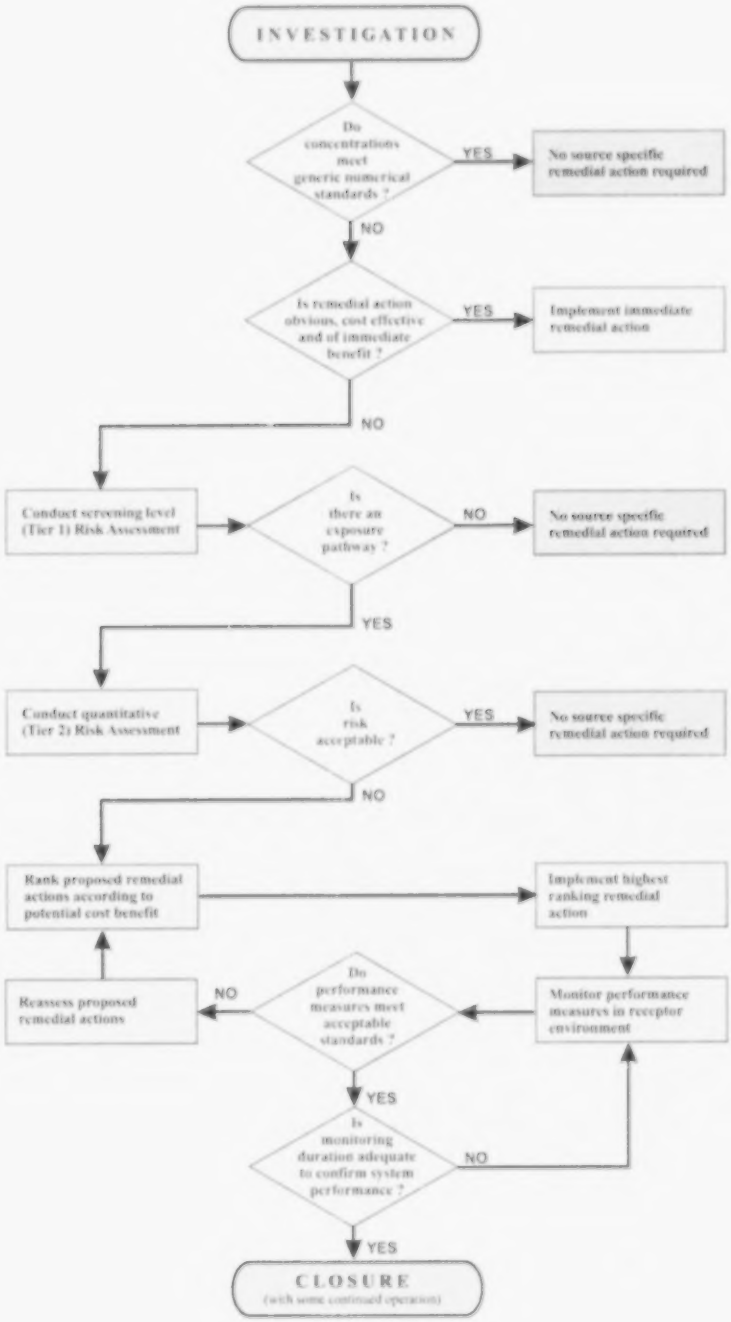
BRITANNIA

OVERALL MINE CLOSURE AND SITE REMEDIATION PROCESS

Golder Associates

FIGURE 4-1

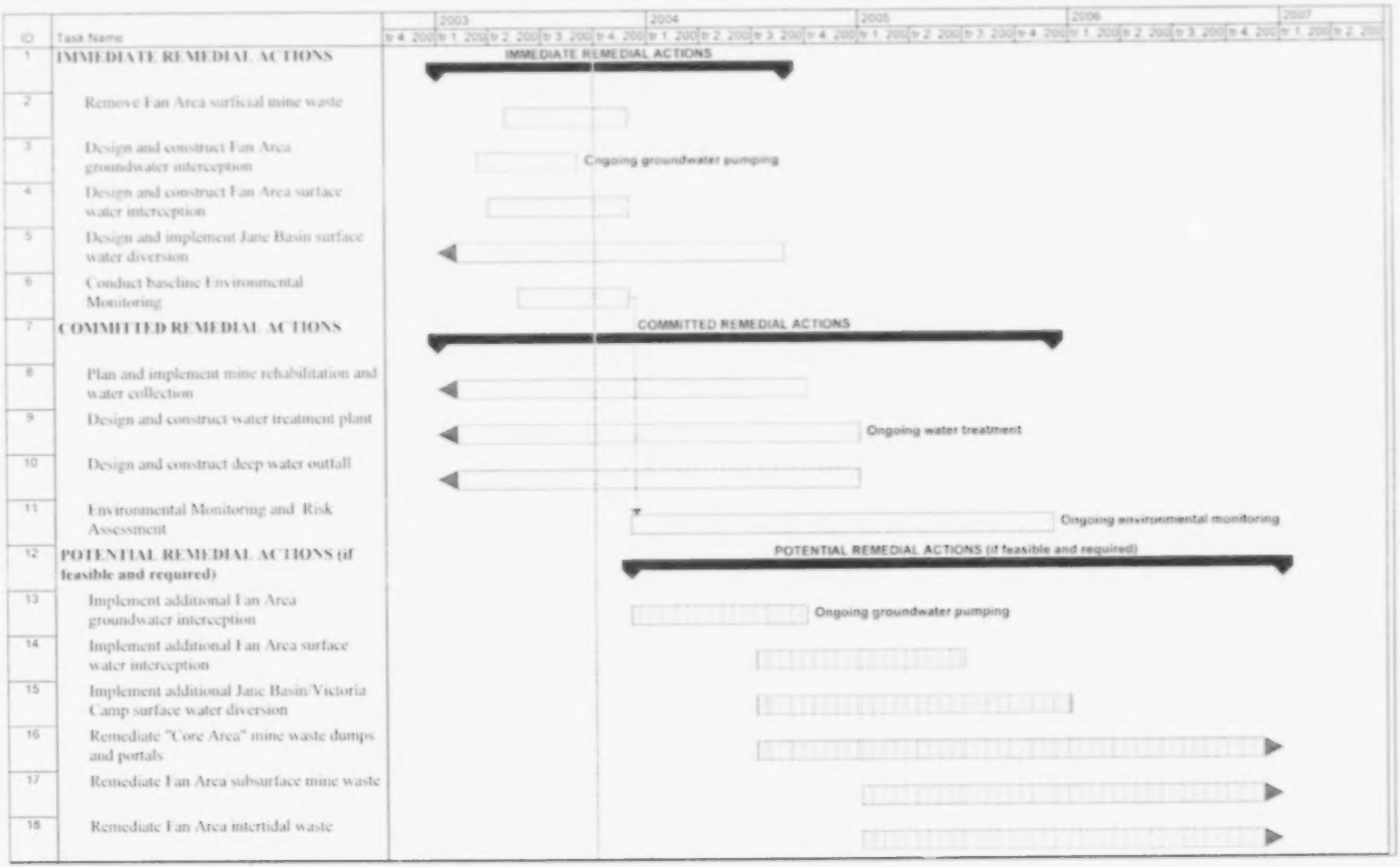


MSRM
REMEDIATION
BRITANNIA

THE MINE CLOSURE & SITE REMEDIATION IMPLEMENTATION PROCESS

Golder Associates

FIGURE 7-1


ID
Task Name
2003
2004
2005
2006
2007
1 IMMEDIATE REMEDIAL ACTIONS
2 Remove Fan Area surficial mine waste
3 Design and construct Fan Area groundwater interception
4 Design and construct Fan Area surface water interception
5 Design and implement Jane Basin surface water diversion
6 Conduct baseline Environmental Monitoring
7 COMMITTED REMEDIAL ACTIONS
8 Plan and implement mine rehabilitation and water collection
9 Design and construct water treatment plant
10 Design and construct deep water outfall
11 Environmental Monitoring and Risk Assessment
12 POTENTIAL REMEDIAL ACTIONS (if feasible and required)
13 Implement additional Fan Area groundwater interception
14 Implement additional Fan Area surface water interception
15 Implement additional Jane Basin/Victoria Camp surface water diversion
16 Remediate "Core Area" mine waste dumps and portals
17 Remediate Fan Area subsurface mine waste
18 Remediate Fan Area intertidal waste
IMMEDIATE REMEDIAL ACTIONS
Ongoing groundwater pumping
COMMITTED REMEDIAL ACTIONS
Ongoing water treatment
Ongoing environmental monitoring
POTENTIAL REMEDIAL ACTIONS (if feasible and required)
Ongoing groundwater pumping

MSRM
REMEDIATION
BRITANNIA

OVERALL MINE CLOSURE AND
SITE REMEDIATION SCHEDULE

Golder Associates

FIGURE 7-2

APPENDIX I

LIST OF REPORTS

SELECTED REPORTS			
Company	**Year**	**Report Title**	**Date**
AMEC	2001a	Action Plan for a Feasibility Study of the Britannia Mine Remediation Project	November 23, 2001
	2002a	Britannia Mine Water Treatment Plant Site Risk Assessment Workshop	May 5, 2002
	2002b	Britannia Mine, Water Treatment Plant, Best Value Decision-Making	June 18, 2002
	2002c	Britannia Mine Water Treatment Plant Sludge Disposal Alternatives	July 2002
	2002d	Britannia Mine Water Treatment Plant Feasibility Study	December 6, 2002
	2002e	Britannia Mine Water Treatment Plant Outfall Hydraulics	December 2, 2002
	2002f	Britannia Mine, Water Treatment Plant, Sludge Disposal Options Study	February 2003
	2003a	Britannia Mine Water Treatment Plant Feasibility Study Addendum 1	February 10, 2003
CEMI	2002a	Pilot Scale Tyesting of the High Density Sludge Process	June 6, 2002
Golder	2003a	Stage 1 Remedial Action Plan, Britannia Mine, Britannia Beach, BC	March 28, 2003
	2003b	Environmental Monitoring Plan Britannia Mine, Subtidal, Intertidal, Fan and Additional Areas	June 6, 2003
Komex	2002a	Britannia Mine Outfall Treatment Plant Discharge Dilution Analysis	July 24, 2002
	2002b	Britannia Outfall Replacement – Comparison of Alternative Sites	December 2002
SRK	2001a	Britannia Remediation Project, Mine Safety Inspection Plan	November 1, 2001
	2002a	Britannia Mine Remediation, 4100 Level Plug Test Application	February 10, 2002
	2002b	Britannia Mine Remediation - Structural Geology	May 9, 2002
	2002c	Britannia Mine Remediation Assessment of Surface Water Diversions in the Jane Basin and Victoria Glory Hole Catchments (Draft)	June 20, 2002
	2002d	Britannia Mine Remediation, Initial Plug Test Report	June 12, 2002
	2002e	Britannia Mine Remediation, Mine Hydrology Report	September 12, 2002

SELECTED REPORTS			
Company	**Year**	**Report Title**	**Date**
SRK	2003a	Britannia Mine Remediation, Mine Safety Inspection Report	January 23, 2003
	2003b	Britannia Mine Remediation Geochemistry and Water Quality of the Mine Workings	February 12, 2003
	2003c	Britannia Mine Remediation, Hydrologic Evaluation	March 26, 2003
	2003d	4100 Level Plug Test, 2002, Britannia Mine	March 25, 2003
USR	2002a	Britannia Contaminated Sites Investigation, Stage I, Preliminary Site Investigation, Britannia Mine Site, BC	January 29, 2002
	2002b	Britannia Contaminated Sites Investigation Fan Area Detailed Site Investigation Britannia Mine Site, BC	June 7, 2002
	2002c	Britannia Contaminated Site Investigation, Tier I Ecological Risk Assessment, Fan Area, Britannia Mine Site, BC	June 7, 2002
	2002d	Britannia Contaminated Sites Investigation, Human Health Risk Assessment, Fan Area, Britannia Mine Site, BC	July 31, 2002
	2002e	Britannia Contaminated Sites Investigation, Fan Area, Remediation Planning Document, Britannia Mine Site, BC	October 31, 2002
URS	2003a	Britannia Contaminated Sites Investigation, Tier 1 Ecological & Human Health Risk Assessment, Additional Areas, Britannia Mine Site, BC	June 6, 2003
	2003b	Britannia Contaminated Sites Investigation Stage II Preliminary Site Investigation and Detailed Site Investigation, Additional Areas, Britannia Mine Site, BC	June 6, 2003
	2003c	Britannia Contaminated Sites Investigation Additional Areas Remediation Planning Document, Britannia Mine Site, BC	June 2003
EVS	2003a	Stage 1 Environmental Monitoring Program (in preparation, title to be finalized)	October 2003
WMC	2002a	Britannia Creek Flood Risk Assessment	July 8, 2002

APPENDIX II

REMEDIATION ORDER OE-16907

Britannia

Issue Date: September 8, 1999 Our File: OE-16097

Amendment Date: January 7, 2000

Tim Drummond
Copper Beach Estates Ltd.
1500 - 1030 West Georgia Street
Vancouver, British Columbia
V6C 2Y3

Re: Remediation Order OE-16097 as Amended January 7, 2000, under the Provisions of Section 27.1 of the *Waste Management Act* - Britannia Mine Site

1. Responsible Persons

Copper Beach Estates Ltd. is the present owner of lands which were part of the former Britannia mine site, and which are considered to be causing pollution and contamination of the receiving environment. For the purposes of this order, COPPER BEACH ESTATES LTD. ("Copper Beach") is considered to be a responsible person.

2. Contaminated Lands and Waterbodies

The acid rock drainage (ARD) resulting from the oxidation of sulphide mineralization exposed to air and water at the the former Britannia mine is one of the worst point sources of metals pollution to the environment in North America. The source of the ARD is the old mine workings of Britannia mine, including the open pits, tunnels and stopes. Mining took place on and within ore bodies located in a ridge between Furry Creek and Britannia Creek, at elevations ranging from 1300 meters above sea level to 450 m below sea level. At present there is inadequate containment or control of the ARD. As a result, this site poses a high risk to the receiving environment. Federal Department of Fisheries and Oceans (DFO) studies have concluded that approximately 2 km of sensitive intertidal salmon habitat adjacent to the site is adversely affected by the discharge of ARD effluent from the site.

As a result of ARD, contaminant levels in Britannia Creek and its tributary Jane Creek, Britannia Bay and Howe Sound exceed current regulatory standards for metals, including copper, aluminum, iron, zinc and manganese. ARD discharges into these waters also result in depressed pH levels. These ARD discharges have resulted in water contamination which is presently toxic to aquatic life in lower Jane Creek, Britannia Creek and adjacent portions of Howe Sound. I am satisfied that the former mine site and the adjacent receiving environment is a contaminated site.

The contaminated lands and waterbodies subject to the requirements of this order are:

2.1 Contaminated Land

2.1.1 Former Britannia Mine Site

The land subject to the requirements of this order are the former Britannia mine site with the exception of

the following:

- Furry Creek Properties
- The Makin Property

Copper Beach is ordered to prepare and submit a plan of the lands which are subject to the requirements of this order to the Regional Waste Manager by October 1, 1999.

2.2 Contaminated Waterbodies

ARD drainage from the former mine exits the site from several portals. However, two portals, the 2200 Level portal which drains into Jane Creek, a tributary of Britannia Creek, and the 4100 Level portal which drains into Howe Sound, contribute the majority of the ARD contaminated effluent currently generated at the site. At present surface runoff from the Jane catchment basin is assumed to be a major contributor to the ARD drainage.

The contaminated waterbodies in the vicinity of the Site subject to the requirements of this order are:

Jane Creek,
Britannia Creek,
and Howe Sound.

and, more specifically, the above areas in which the surface water or the underlying sediments contain metals at concentrations exceeding:

- special waste levels;
- standards of the Contaminated Sites Regulation;
- the Average Effects Level (AEL) or midpoint between the Interim Sediment Quality Guidelines (ISQG) and Probable Effects Level (PEL) for marine sediments provided in A Compendium of Working Water Quality Guidelines for British Columbia: 1998 Edition. The ISQG is also referred to as the Threshold Effects Level;
- the approved water quality guidelines provided in the British Columbia Water Quality Guidelines (Criteria): 1998 Edition; or,
- the working water quality guidelines provided in A Compendium of Working Water Quality Guidelines for British Columbia: 1998 Edition.

These lands and waterbodies comprise the site which is the subject of this order. The full extent of the contamination of the lands and waterbodies which are the subject of this order has not yet been fully determined.

3. Site Investigations

Copper Beach is ordered to undertake the following site investigation studies to identify the impact of the ARD and the Works on the receiving environment.

3.1 Environmental Effects Monitoring Plan

An environmental effects monitoring plan shall be submitted to the Regional Waste Manager by January 30, 2000, for approval. The monitoring plan shall be designed to assess the water and sediment quality in Britannia Creek and Howe Sound once the effluent collection and treatment works are operational, for the purposes of determining if further remediation is necessary to protect the environment. Implement the approved plan.

3.2 Site Hydrology and Hydrogeology Report

A site hydrology and hydrogeology report shall be submitted to the Regional Waste Manager by June 2, 2000, for approval. The report shall provide a detailed site hydrologic and hydrogeologic assessment of the proposed Works and measures for effluent management. The assessment shall include, but shall not be limited to, the following:

-surface hydrology field investigations and detailed site hydrology assessment;
-an assessment of the potential of the Works to impact local surface water quality, including Jane Creek, Britannia Creek, Mineral Creek, Furry Creek, and any other local creek system, and the community drinking water supplies at Britannia Creek, Mineral Creek, and Furry Creek, and any recommended monitoring of these systems in addition to the monitoring already required by this order; and,
-an assessment of internal mine hydrogeology associated with internal mine flow paths including: potential to discharge from the mine works to the environment, the 2200 level diversion and use of internal workings as a reservoir.

4. Consideration for Remediation Methods

The general principles that apply to the remediation of all contaminated sites in BC are outlined in section 28.2 of the *Waste Management Act*. Section 28.2 establishes a clear preference for permanent solutions and directs managers to evaluate applications under the Act in accordance with this principle. By definition, remedial solutions that achieve compliance with the numeric standards provide maximum permanence.

Permanent solutions as defined under Ministry policy for the purposes of interpreting section 28.2 are those solutions that most effectively reduce:

-contaminant mass, and most importantly the mass of hazardous contaminants and special wastes; -present and future risks to human health and the environment; and
-the amount of future energy, maintenance and monitoring required to ensure the continued viability of the proposed measures.

The ARD problem at the Site has existed for decades and been the subject of numerous studies.

Since 1995, Environment Canada, British Columbia Ministry of Energy and Mines (BCMEM), and British Columbia Ministry of Environment, Lands and Parks (BCMELP), have cooperated in jointly trying to define the ARD problem, and the necessary works and associated costs for the consolidation, control and treatment of the ARD before discharge into the receiving environment. The goal of these cooperative efforts was to reduce the level of contaminants in the discharge to approved standards. A report dated March 1998 by HA Simons concluded that the high density sludge lime process was the best process to address the ARD effluent discharge at the Site.

The Reclamation and Remediation Permit Application dated March 1999, prepared by HA Simons for Copper Beach, includes a proposal to construct effluent treatment works to consolidate, collect, control, contain and treat the ARD. The treatment process will utilize the high density sludge lime process. This is the process recommended as the optimal process to remediate the ARD contaminated effluent presently discharging from the Site in the March 1998 HA Simons Report.

Copper Beach proposed constructing an effluent treatment plant at the 4100 level, northeast of and adjacent to the BC Mining Museum. The collection works would divert the majority of the ARD to this site. The proposed plant would operate 24 hrs a day, seven days a week. I am satisfied that the construction and operation of the proposed collection works and HDS treatment plant will significantly reduce the impact of ARD contamination on the receiving environment.

5. Remedial Requirements

In view of the immediate significant risks posed by the ARD contamination on the above lands and waterbodies, Copper Beach is hereby ordered to carry out the following immediate remedial measures.

5.1 Immediate Remedial Measures

5.1.1 Effluent Collection and Treatment Remedial Works (the "Works")

By March 31, 2000, Copper Beach shall prepare and submit to the Regional Waste Manager, for approval, detailed remedial workplans for the design and construction of the necessary Works to collect the acid mine drainage and to treat the acid mine drainage to meet the requirements of the attached effluent permit PE-12840. I order that the approved Works be completed and operational by August 31, 2000.

5.1.2 4100 Plug Test Report

A 4100 foot plug test report shall be submitted to the Regional Waste Manager by June 7, 2000. The test shall assess the equalization and emergency storage potential within the internal mine workings, and include assessment of the potential for adverse environmental impacts. The report shall also include any necessary measures, including monitoring, to address any potential adverse impacts. The internal workings of the mine shall not be modified for use for long-term flow equalization or emergency storage until the report is approved by the Regional Waste Manager.

5.1.3 2200 Level Diversion Report

A 2200 level diversion report shall be submitted to the Regional Waste Manager for approval by May 26, 1999. The report shall provide a detailed plan to prevent the 2200 level discharge of Acid Rock Drainage from entering the environment without treatment. The report shall also provide a plan for the prevention of the release of any Acid Rock Drainage to the environment as a result of diversion works. Implement the approved plan.

5.1.4 Effluent Treatment Works Design Report

A treatment plant design criteria report shall be provided to the Regional Waste Manager by February 29, 2000. The plan shall include the design for the treatment plant and schematic plans. The report shall provide the basis for the design criteria particularly the design flow and consideration of the mine hydrology including diversion assessments and internal mine storage tests.

5.1.5 Contingency Plan

A contingency plan shall be submitted for the approval of the Regional Waste Manager by February 29, 2000. The contingency plan shall provide the actions which Copper Beach will implement to ensure that all Acid Rock Drainage is collected and optimally treated under all reasonably foreseeable circumstances, including but not limited to the following situations: 1) new or increased Acid Rock Drainage discharges from portals or locations at the site due to changes in internal mine hydrology; and 2) failure of the preferred method for collecting drainage from the 2200 portal.

5.1.6 Permit Applications and Authorizations

Subject to the terms of this order, Copper Beach is authorized to discharge the effluent treated by the Works in accordance with the terms and conditions of Permit PE-12840 appended to this Order.

5.1.7 Initiation of Treatment Plant Engineering Design Work

Design work related to the treatment plant works shall be initiated by January 11, 2000. The professional engineer responsible for the design work shall provide a letter to the Regional Waste Manager by January 15, 2000, advising that the required design work related to the treatment plant is proceeding in a manner that will achieve compliance with this Order.

5.2 Long Term Remedial Measures

5.2.1 Acid Rock Drainage Minimization Report

An Acid Rock Drainage Minimization Report shall be submitted to the Regional Waste Manager, for approval by June 15, 2000. The report shall include an assessment of potential measures, and make recommendations, to reduce the generation of acid rock drainage. The report shall examine measures to cover exposed sulphide mineralization to reduce contact with water and air. The report shall also examine measures to divert uncontaminated water away from sulphide mineralization including the open pits and underground workings of the mine. Implement the approved recommendations of the report.

6. Works Operational Requirements

In order to ensure that the Works achieve their stated goal of reducing the impact of ARD on the receiving environment to acceptable levels I order that Copper Beach conduct the operations of the treatment and collection plant in conformity with the following requirements:

6.1 Treatment Plant Operating Manual

Copper Beach shall submit a treatment plant operating manual to the Regional Waste Manager for approval. The manual shall provide procedures to ensure that the treatment plant is operated efficiently for the purpose of minimizing environmental impact. The manual shall be submitted to the Regional Waste Manager within 30 days of providing written notice that the treatment plant is constructed and operational. Copper Beach shall operate the plant in accordance with the approved manual.

6.2 Maintenance of Works

Copper Beach shall inspect the authorized works regularly and maintain them in good working order. Copper Beach shall notify the Regional Waste Manager of any malfunction of these works and prepare and submit to the Regional Waste Manager interim and final plans to address the environmental impact of any such malfunction.

6.3 Transfer of Ownership of Authorized Works

The ownership of the authorized works shall not be transferred without the written consent of the Regional Waste Manager.

6.4 Treatment Plant Solids Disposal

Solids, including filter cake or sludge, from the effluent treatment works shall be re-processed for metal recovery, or alternatively, shall be disposed of at a site and in a manner acceptable to the Regional Waste Manager. Within 30 days of providing a written notice to the Regional Waste Manager notifying that the effluent treatment plant, and associated works are constructed and operational, Copper Beach shall sample the solids generated by the treatment plant, and analyze the solids for total metals and leachable metals to the satisfaction of the Regional Waste Manager. The analytical results, interpretation, waste characterization and relevant operating conditions of the plant at the time of sampling, shall be provided in a report to the Regional Waste Manager within 30 days of the sample being taken.

Copper Beach shall make ongoing investigations into the re-use of the treatment plant solids as an alternative to landfilling, until a re-use alternative is found. Copper Beach shall maintain records of these investigations, and provide an annual summary of the investigations.

6.5 Neutralization Waste Materials

No wastes shall be used for the purpose of the neutralization of the Acid Rock Drainage, either in partial or full replacement of lime, unless written approval is obtained from the Regional Waste Manager, prior to use of the waste. The Regional Waste Manager may require further studies or make other requirements, to ensure that the environment is protected.

6.6 Process Modifications

Copper Beach must inform the Regional Waste Manager in writing of any proposed changes in the treatment process. No changes in process may be made without the written approval of the Regional Waste Manager.

6.7 Discharge Outfall Pipe Inspection and Reporting

Copper Beach shall have the outfall inspected for its condition and integrity once each two calendar years by an independent, registered, qualified professional, to ensure the outfall is in good condition. An inspection report shall be submitted to the Regional Waste Manager within 30 days after the inspection date. The report shall also make recommendations with a schedule for implementation of actions to improve any inadequacies of the outfall. Copper Beach shall implement the recommendations in accordance with the schedule. The first report shall be submitted to the Regional Waste Manager prior to construction of the treatment plant, and shall include a confirmation of the location and design of the outfall, in addition to the condition and integrity of the outfall.

7. Monitoring and Reporting Requirements

The following monitoring program shall be undertaken by Copper Beach. The Regional Waste Manager may modify the monitoring program based on the results submitted as well as any other pertinent information obtained by the ministry. In the event that wastes are deposited in the landfill authorized by permit PR-15938, additional monitoring may be required, particularly if not addressed by the monitoring programs required under PR-15938.

7.1 Monitoring

7.1.1 Discharge Sampling Sites

Sampling sites shall be located as follows :

Location	Site Reference No.	Sampling Site No.
Discharge Outfall	E237898	1.1

7.1.2 Discharge Sampling and Analyses

Copper Beach shall install suitable sampling facilities, and upon submission of written notice from Copper Beach advising that the effluent treatment plant, and associated works including collection works, are constructed and operational, Copper Beach shall obtain and analyze the samples according to the following schedule:

7.1.2 Discharge Sampling and Analyses

Copper Beach shall install suitable sampling facilities, and upon submission of written notice from Copper Beach advising that the effluent treatment plant, and associated works including collection works, are constructed and operational, Copper Beach shall obtain and analyze the samples according to the following schedule:

Parameter	Sample Site No. 1.1
pH	C
conductivity	C
temperature	C
total suspended solids	W
dissolved solids	W
Parameter (cont'd)	Sample Site No. 1.1

total metals*	W
dissolved metals*	W
sulphate	W
LT_{50} fish bioassay	M
48hr LC_{50} daphnia bioassay	M

where: C=Continuous, D=Daily, W=Weekly, M=Monthly, Q=Quarterly

metals*=metals analysis shall include aluminum, arsenic, barium, cadmium, copper, chromium, iron, lead, manganese, nickel, selenium, and zinc

Discharge 1.1 (sample site 1.1) shall also be analyze for all parameters required above when a discharge out of the normal course of events occurs.

The Regional Waste Manager may consider revising the frequency and analyses of monitoring after the first twelve months of submitted data.

7.1.3 Discharge Flow Measurement

Upon submission of written notice from Copper Beach advising that the Acid Rock Drainage and landfill leachate treatment plant, and associated works including collection works, are constructed and operational, Copper Beach shall continuously measure the flow of treatment plant discharge 1.1.

The method of flow measurement shall be acceptable to the Regional Waste Manager.

7.1.4 ARD and Receiving Environment Sampling Sites

Sampling sites shall be located as follows (as shown on Site Plan A):

Location	Site Reference No.	Sampling Site No.
2200 Drainage	221807	1.2
4100 Drainage	221806	1.3
Jane Creek (upstream of 2200 portal inflow)	221830	1.4
Britannia Creek (upstream of Jane Creek)	221832	1.5
Britannia Creek (at townsite bridge)	221829	1.6

7.1.5 ARD and Receiving Environment Sampling and Analyses

Copper Beach shall install suitable sampling facilities, and upon completion and operation of the effluent treatment plant, and associated works including collection works, Copper Beach shall obtain and analyze the samples according to the following schedule:

Parameter	Sample Site No.				
	1.2*	1.3	1.4	1.5	1.6
pH	M	M	M	M	M

conductivity	M	M	M	M	M
temperature	M	M	M	M	M
total suspended solids	M	M	M	M	M
sulphate	M	M	M	M	M
dissolved solids	M	M	M	M	M
dissolved metals*	M	M	M	M	M
total metals*	M	M	M	M	M

where: C=Continuous, D=Daily, W=Weekly, M=Monthly, Q=Quarterly, S=Semi-Annually

metals*=metals analysis shall include aluminium, arsenic, barium, cadmium, copper, chromium, iron, lead, manganese, nickel, selenium and zinc

1.2*=The discharge from the 2200 portal does not have to be sampled and analyze if the portal is plugged such that no drainage flows from the portal either into collection works or into the environment.

7.1.6 ARD and Receiving Environment Flow Measurement

Upon completion and operation of the effluent treatment plant, and associated works including collection works, and prior to discharge to the landfill, Copper Beach shall continuously measure the flow from the 2200 portal (sampling site 1.2), the flow from the 4100 portal (sampling site 1.3), the flow in Jane Creek at the 2200 foot level (sampling site 1.4), and the flow in Britannia Creek at the beach level (sampling site 1.6).

The method of flow measurement for all sampling sites shall be acceptable to the Regional Waste Manager.

7.1.7 Meteorological Measurement

Measure the daily precipitation and hourly temperature at the 2200 foot level, and the daily precipitation and hourly temperature at the northern edge of Jane Basin.

7.2 Monitoring Procedures

7.2.1 Sampling and Flow Measurement

Sampling is to be carried out in accordance with procedures described in the latest version of "British Columbia Field Sampling Manual for Continuous Monitoring plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 1996 Edition (Permittee)," or by suitable alternative procedures as authorized by the Regional Waste Manager. A copy of the above manual may be purchased from Queen's Printer Publications Centre, P. O. Box 9452, Stn. Prov. Govt. Victoria, British Columbia, V8W 9V7 (1-800-663-6105 or (250) 387-6409). A copy of the manual is also available for inspection at all Pollution Prevention offices.

7.2.2 Chemical Analyses

Analyses are to be carried out in accordance with procedures described in the latest version of "British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials (March 1994 Permittee Edition)", or by suitable alternative procedures as authorized by the Regional Waste Manager.

A copy of the above manual may be purchased from Queen's Printer Publications Centre, P. O. Box 9452, Stn. Prov. Govt. Victoria, British Columbia, V8W 9V7 (1-800-663-6105 or (250) 387-6409). A copy of the manual is also available for inspection at all Pollution Prevention Offices.

7.3 Reporting

7.3.1 Quarterly Reporting

Maintain data of analyses and flow measurements for inspection and submit the data, suitably tabulated, to the Regional Waste Manager for the previous calendar quarter. For continuous analytical measurements, the minimum, maximum, and average daily values shall be presented. For continuous flow measurements, the total daily volume discharged shall be presented. All data shall be compared to the permitted levels where applicable. Any non-compliant data shall be clearly indicated and explained, and the necessary actions and schedule to achieve consistent compliance shall also be provided. All reports shall be received by the manager within 31 days of the end of the reporting period.

7.3.2 Annual Reporting

Copper Beach shall retain an independent, qualified, and registered professional to prepare a treatment plant environmental report for each calendar year. The report shall be submitted and received by the Regional Waste Manager within 90 days of the end of the previous calendar year. The report shall include, but not be limited to:

-a summary of all monitoring data with an interpretation of the data, and comparison of the data with applicable permit limits and criteria;

-a correlational analysis between primary parameters of concern (concentrations of zinc and copper) and real-time data (eg. pH);

-a summary of the efforts to re-use treatment plant solids as an alternative to landfilling; and,

-recommendations for any necessary corrective actions to minimize the potential for environmental impact, to improve the monitoring information and further investigations for sludge re-use. The report shall be submitted to and received by the Regional Waste Manager within 90 days of the end of the previous calendar year.

The first calendar year for which a monitoring report shall be submitted to the Regional Waste Manager is the year in which the Works become operational.

8. Progress Reporting

For project tracking and review, written progress reports shall be submitted on the first Monday of every month from the date of issuance of this Order until such time as the Regional Waste Manager determines. Monthly progress reports shall summarize work completed in the previous month and that proposed for the upcoming month. The monthly progress reports shall also indicate if funding is in place for the work proposed for the upcoming month. Where delays in previously scheduled work have occurred or are predicted to occur, reasons for the delays shall be provided. Progress reports may be submitted electronically.

9. Availability of Required Reports, Assessment, Plans and Manuals

Copper Beach shall provide copies of Reports, Assessments, Plans and Manuals required by this Order and any other submissions required by this Order to concerned persons for their review and comment, as directed by the Regional Waste Manager.

10. Financial Security

Prior to the operation of the Works, Copper Beach shall provide security in an amount and form approved by the Regional Waste Manager.

11. Additional Provisions

All reports and plans submitted under the requirements of this order shall be to the satisfaction of the Regional Waste Manager and be prepared and stamped, as appropriate, by a qualified and registered professional with demonstrable experience acceptable to the Regional Waste Manager.

This Order is without prejudice to any further action that may be taken under the *Waste Management Act*. Contravention of this Order is a violation under the *Act* and is subject to legal action.

This Order does not authorize entry upon, crossing over, or use, for any purpose, of private or crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority rests with the responsible parties. It is also the responsibility of the ordered parties to ensure that all activities conducted under this Order are carried out with due regard to the rights of third parties, and comply with other applicable legislation that may be in force, including, but not limited to, the Mines Act and the federal *Fisheries Act*.

I reserve the right at any time to amend this Order.

This decision may be appealed by persons who consider themselves aggrieved by the decision in accordance with Part 7 of the *Waste Management Act*. Notice of the appeal must (1) be in writing, (2) include the grounds for appeal, (3) be directed by registered mail or personally delivered to the Chair, Environmental Appeal Board, 4th Floor 836 Yates Street, Victoria, British Columbia, V8V 1X5, (4) be delivered within 30 days from the date notice of the decision is given, and (5) be accompanied by a fee of $25.00, payable to the Minister of Finance and Corporate Relations. Section 47 of the Act states that "a(n) appeal taken under the Act does not operate as a stay or suspend the operation of the decision being appealed unless the person or board to whom the appeal is taken orders otherwise."

Yours truly,

R.H. Robb

Assistant Regional Waste Manager

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Please email: site@gems6.gov.bc.ca with any comments or questions.

Last Updated: October 24, 2000

APPENDIX III

REMEDIATION PLANNING AND IMPLEMENTATION DOCUMENTATION ROADMAP

Remediation Planning and Implementation Documentation Roadmap

Strategic Documents	Planning Documents (Action Plans)	Implementation Documents (Workplans)
Action Plan for a Feasibility Study: Britannia Mine Remediation Project (November, 2001)		• Various contractor technical study workplans: SRK, URS, WMC and AMEC (2001/2)
Overall Mine Closure and Remediation Plan (September, 2003)	Stage 1 Remedial Action Plan (March, 2003)	• Soils Management, BBHS Lands (May, 2003) • Soils Management, BMARC Lands (May, 2003) • South Fan Area Groundwater Investigations: Long-term Pumping Test Program (May, 2003), Rev 1 (August, 2003) • Sediment Control and Surface Water Runoff (October, 2003) • *Jane Basin Soil Disposal: Road Upgrades, Soil Transport and Disposal (Q4, 2003)*
	Acid Rock Drainage Remedial Action Plan (Q4, 2003)	• *Jane Basin Surface Water Diversions: East Bluff, Upper Jane Creek (Q4, 2003)* • *Water Treatment Plant Procurement and Construction (Q4, 2003)* • *Stage 2 Mine Rehabilitation (Q1, 2004)* • *Deep Outfall Assessment (Q4, 2003)* • *Deep Outfall Procurement and Construction (Q1, 2004)*
	Fan Area Remedial Action Plan (Q4, 2003)	• *Stage 2 Groundwater Management (Q4, 2003)* • *Stage 2 Soils Management (Q1, 2004)*
	Additional Areas Remedial Action Plan (Q2, 2004)	• *Surface Water Management (2004)* • *Soils Management (2004)* • *Groundwater Management (2004)*
	Environmental Monitoring Plan, Sub-tidal, Inter-tidal, Fan and Additional Areas (June, 2003)	Stage 1 Environmental Monitoring Program (Baseline) EVS Workplan (Q3, 2003)
		Stage 2 Environmental Monitoring Program and Tier 2 Risk Assessment (Q4, 2003)
	Mine Safety Action Plan	*Mine Safety Workplan (Q1, 2004)*
Remediation Priority Plan Based on Stage 2 Environmental Monitoring and Tier 2 Risk Assessment (October, 2005)		

Note: Anticipated documents shown in italics with approximate issue dates. These are indicative only, as titles may change and documents may be added or removed to suit prevailing project requirements and schedule.

APPENDIX IV

EXAMPLE WORKPLAN

SOUTH FAN AREA GROUND WATER INVESTIGATIONS:

LONG TERM PUMPING TEST PROGRAM,
STAGE 1 REMEDIAL ACTION PLAN
BRITANNIA MINE, BRITANNIA BEACH, BC

Golder Associates Ltd.

500 – 4260 Still Creek Drive
Burnaby, British Columbia, Canada V5C 6C6
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REPORT ON

WORKPLAN FOR SOUTH FAN AREA GROUNDWATER INVESTIGATIONS: LONG-TERM PUMPING TEST PROGRAM, STAGE 1 REMEDIAL ACTION PLAN BRITANNIA MINE BRITANNIA BEACH, BC

Submitted to:

Ministry of Sustainable Resource Management
Victoria, BC

DISTRIBUTION:

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1.0 BACKGROUND

The Stage 1 Remedial Action Plan (Stage 1 RAP) for the Fan Area of the Britannia mine site (the Site) was submitted to the Regulator on April 8, 2003. The plan included a number of components relating to contaminated soil management, surface water drainage improvements and groundwater capture in the south Fan Area. The groundwater capture component has a dual purpose:

- Provide an interim means of capturing a portion of the contaminated groundwater flux to Howe Sound from the south Fan Area by a pumping well; and
- Provide additional data on the groundwater system to allow further evaluation of the engineering aspects of a long-term groundwater capture system for this area of the Site.

The Stage 1 RAP contained an outline of the proposed groundwater pumping program (Stage 1 RAP, Section 4.3 and Appendix 5). This workplan expands on that outline in sufficient detail to allow the Regulator to issue an Approval to undertake the program.

2.0 INTRODUCTION

It is anticipated that an effective groundwater capture (pump and treat) system for the south Fan Area at Britannia (Figure 1) will be a complex system to design, operate and maintain because of a number of factors including:

- Heterogeneous aquifer resulting in complex flow paths.
- Proximity to coastline: 100% groundwater capture will result in sea water intrusion.
- Poor quality water (metal-contaminated, acidic) will likely cause significant encrustations on the screens that will reduce system efficiency over time, and will require continual maintenance and possibly replacement.
- Loss of yield from individual wells (due to encrustations, etc) would need to be identified and mitigated in the system by careful well design and construction, system component redundancy and/or increased operation and maintenance.
- Groundwater with high chloride content will affect the design and specifications of the water treatment plant components and/or operational efficiency of the treatment system.

In order to design, optimize, manage and cost the system, additional geological, hydrogeological and geochemical data are required. These data would be used to design a numerical hydraulic model that would better represent the complex hydrogeological conditions at the Site. This model would simulate variable density flow and seawater intrusion.

This work plan consists of four main tasks:

- Geophysical surveys;
- Drilling and Installation of a test/pumping well;
- Long-term Pumping test, including geochemical sampling and analyses;
- Analysis and numerical modelling; and
- Preliminary groundwater control system design and reporting.

Each of these tasks is described in the following sections.

If the pumping test demonstrates that long-term pumping from the well(s) in the south Fan Area is a viable and effective method of reducing the metal loading to Howe Sound, the Stage 1 RAP allows for this pumping to continue as an interim remedial measure until a long-term system is designed, installed and commissioned. This is referred to as Task 5 in the following sections. During these test activities, the pumped water will be discharged to the existing deep outfall at the Britannia Creek. Discharge from a long-term installation would be directed to the ARD water treatment plant except during 'emergency' conditions where the plant was running at full capacity.

3.0 TASK 1 - GEOPHYSICAL SURVEY

This task consists of a seismic survey to determine the location of the bedrock beneath the fans and an EM survey to determine the location of the seawater/freshwater interface. The geophysics field work was completed prior to any pumping test so that 'static' conditions in the aquifer could be assessed, i.e. with no disturbance to the ambient disposition of the coastal saline interface.

3.1 Scope of Work

The objective of this survey was to investigate the depth to bedrock across the Britannia fan, and to investigate the depth to the seawater/freshwater interface with increasing distance from the shoreline. The purpose of the survey was to provide further subsurface geometrical characterization, and to provide constraints on hydrogeological modeling. The survey workplan involved bedrock profiles across the Britannia fan, and seawater/freshwater profiles, where these could be done given the site constraints.

3.2 Geophysics Workplan

The depth to bedrock survey was conducted using the seismic refraction method. This made use of a range of seismic sources, including weight drop devices, Seisgun, vibroseis, or small charges, as needed. The final geophone positions were determined in the field depending on surface conditions. The initial proposed layout is provided (Figure 2). One of the key limitations was train/vehicle noise, and may have resulted in lines being moved further from these noise sources.

Where possible the seawater/freshwater interface survey was conducted with the electrical resistivity imaging (ERI) method. This detects differences in resistivity and provides cross-sections similar to refraction sections. This method uses continuous cables, and depended on locating suitable culverts beneath the traintracks/highway in order to work. Otherwise, vertical resistivity profiles will be used to obtain the depth to saltwater at discrete points to build a profile.

Positioning was acquired by the field crew using DGPS, and stakes were left on site for subsequent survey if accuracies better than 1 metre are required.

3.3 Personnel

The geophysical team consisted of at least one Golder geophysicist and one or two field assistants for the duration of the survey. Rob Luzitano, Charlie Domingues, and Heather Crow will undertake the field data acquisition and processing, with review by Jeffrey Schmok (Associate) and/or Dr. Michael Maxwell (Associate).

3.4 Schedule

The geophysics field work component is complete and data processing is being finalized.

3.5 Deliverables

The primary deliverable of the geophysical work program will be a factual report containing the survey methods and results, comprising:

- A plan map of the survey area, completed with UTM coordinates;
- Figures showing the seismic profiles with a bedrock interpretation; and
- Profiles showing the ground and saltwater interface perpendicular to the shoreline.

4.0 TASK 2 – DRILLING AND WELL INSTALLATION

This task will consist of drilling, installation, and development of one pumping well and one observation well.

4.1 Pumping Well

The pumping well will be used for a long-term pumping test, and later will become part of the groundwater extraction system. The new well will be drilled about 5 m to the south from the existing pumping well EX-1 located on the Crown Land, west of the BC Rail R-o-W. It will be drilled in 0.4 m diameter to approximately 14 m through fill materials in the concentrate wharf, comprised of silt, sand, and tailings. V-wire 30 slot 316 stainless steel screen will be installed from about 6 to 11 m depth, with a 3 m long sump at the bottom.

A new well is required because the existing pumping well installed in 2002 as part of the detailed site investigations is not suitable for a long-term pumping program. Because of the existing slot size, screen material and diameter, the test results of the planned long-term pumping test may not provide the quality of data needed to evaluate the groundwater conditions and sea water influx. A larger diameter well with stainless steel screen is considered to be the best means of obtaining high quality data needed to properly model the drawdown and "mounding" of the sea water interface. This is critical to both the evaluation of the benefits to be derived from groundwater extraction, and to the design of an effective and efficient long-term pumping program.

4.2 Observation Well

The observation well will be drilled about 5 m to the NW from the existing monitoring well MW01-03 as a replacement/supplement to this well. Based on the samples recovered during drilling of the monitoring well MW01-03, it appears that the well screen has been completed within the fill material containing concentrate, and the hydraulic response at this location is not representative of the fill materials of the south Fan Area. The new observation well will be completed in materials similar to those intercepted in the other boreholes completed in the area of the concentrate wharf.

Both, the pumping well and the observation well will be developed following installation to remove drill cuttings and materials introduced during drilling and well installation.

5.0 TASK 3 - PUMPING TEST AND WATER SAMPLING

This task will consist of installation of a submersible pump in the new pumping well, step-drawdown test, and a long-term pumping test. . The pump, the riser pipe, and the wellhead flange will be constructed of 316 stainless steel to prevent damage from corrosion.

Discharge from the well will be piped to the manhole located near the Highway 99 bridge over Britannia Creek. The temporary forcemain will be constructed of 100 mm diameter PVC. To prevent freezing, the line will be buried about 0.30 m below ground surface. The power for the pumping system will be provided from a connection to the power grid in the south Fan Area. A meter will be installed at the connection point to monitor the power consumption.

Water levels will be monitored in observation wells and the pumping well (Figure 3) during the pumping test and water samples will be collected to assess water chemistry and the potential for well deterioration over time. Specifically this task will consist of the following:

- Dedicated pressure transducers will be installed in a selected number of monitoring wells proximal to and distal to the pumping well, and also in the pumping well prior to and for the duration of testing to assess tidal effects and aquifer response.

- A step pumping test will be conducted to assess initial well efficiency and changes in well efficiency over time as an indication of clogging of the well screen and/or interstices in the aquifer proximal to the well screen. The test will consist of at least three steps with each step at least 60 minutes in duration. This test will also be used to establish optimum pumping rates for the long-term pumping test. From data provided from the URS pumping tests conducted in 2002, it is anticipated that pumping rates for the step tests will likely range between 50 and 200 USgpm.

- Following the step-test, a long-term pumping test will be conducted. Initially the well will be pumped at a low rate (compared to the maximum pumping rate indicated by the step pumping test) so that upwelling of the seawater interface is minimized and so that aquifer parameters can be determined. Water levels in all nearby wells would be measured throughout the test and field parameters such as pH, DO, TOC, electrical conductivity, redox potential, would be measured at least once a day. We anticipate that this portion of the long-term pumping test will be approximately one week in duration.

- After approximately one week, the pumping rate will be increased to induce upwelling of the saline interface. Field parameters will be used to monitor this upwelling. This phase of the test is expected to be several weeks in duration. These data will be used to calibrate the variable density numerical model.

- Water samples will be collected prior to and during the pumping tests. The analyses of these samples will be used to assess the potential for encrustations forming on the well screens and to characterize the geochemistry of the aquifer. These analyses would consist of major anions and a metal scan.

- Water samples will be tested using the BART testing method. More information on this is presented in http://www.dbi.ca. These tests are conducted to determine the presence and type of bacteria present in the water that may cause plugging of the well screens. If the bacteria can be identified, appropriate remedial and/or maintenance measures can be developed for a pump-and-treat system installed at the Site.

- Should information gained from the fieldwork program conducted on the new pumping well, or from data analysis and preliminary modelling (Task 3, below), indicate that additional pumping and/or monitoring wells are required to provide essential data for the groundwater study, these will be added to the program.

Groundwater samples taken during the DSI in 2002 indicated that the groundwater in the concentrate wharf in the vicinity of well EX1 had a pH of 3.5 and had elevated metals (46 mg/L aluminum, 14 mg/L copper, 43 mg/L iron, 20 mg/L zinc). However, the pumping test conducted in well EX1 at that time was of short duration (4 hours) and the samples collected may not be representative of groundwater that would be extracted from the well during long-term pumping. Groundwater samples will therefore be taken throughout the pumping test program to allow a more representative assessment of the groundwater chemistry. In addition, a range of field parameters including pH, DO, TOC, electrical conductivity, and redox potential will be measured at the wellhead.

Groundwater samples collected during the later part of the pumping test, when seawater intrusion will be induced, will be used to assess whether this groundwater can be discharged via the deep outfall, without treatment. This assessment will be required for the evaluation of the "scavenger well" option. Should treatment of the seawater be required than this option may not be practicable.

Laboratory analyses of the water samples will be similar to those undertaken during the pumping test conducted by URS in well EX-1. They will include major anions and dissolved metals (Trace-level ICP).

6.0 TASK 4 – DATA ANALYSIS & NUMERICAL MODEL

This task will consist of a review of the pumping test data using a range of standard analytical techniques, and the development, calibration and predictive use of a three-dimensional hydrogeological model. The model will be developed using FEFLOW, a finite-element numerical code that is capable of simulating density-coupled groundwater flow and transport under a variety of boundary conditions. This model will account for both tidal response and seawater intrusion. It will be used to evaluate, design and optimize the groundwater capture system.

Data collected during Tasks 1, 2 and 3 will be used to establish the thickness and hydrogeological properties of the fan and the initial location of the sea-water interface. The location of the seawater interface and the aquifer response during the pumping test, together with the tidal response of the aquifer, will be used to calibrate the FEFLOW model. Once the model had been calibrated it will be used to predict the response of the hydrogeological system to several groundwater capture scenarios. These may include multiple well arrays in a variety of configurations and pumping ratios to optimize a long-term groundwater capture system in the south Fan Area.

Because of the limits imposed on a groundwater capture system at the Site due to seawater intrusion, which will not allow a 100% capture by a simple pumping well array, alternative capture designs will need to be considered and evaluated. One alternative design to be evaluated will consist of two lines of wells and/or drains. The first line of wells and/or drains would be located close to the shoreline. These wells are referred to as "scavenger wells" and they would be pumped at a sufficiently high rate to purposely develop a permanent seawater wedge along the shore that would act as a barrier to freshwater (metal-contaminated groundwater) flowing towards the shoreline. A second line of wells and/or drains would collect the freshwater on the land side of this barrier. The advantage of this system is that the freshwater is forced upwards because of the presence of this saltwater barrier. The second line of drains/wells are only pumped at a rate that is sufficient to capture this upward flowing water, thereby minimizing the pumping rate and the potential for seawater intrusion into the second row of wells/drains. This method maximizes the pump-and-treat capture of the upland groundwater (metal-contaminated), while minimizing treatment requirements. In addition, barrier wall/pumping well array combinations will be evaluated, together with simple pumping well arrays.

7.0 TASK 5 – PRELIMINARY DESIGN AND REPORTING

In this task, the preferred option or options determined in Task 4 for capture of the upland groundwater from the south Fan Area will be evaluated further. The approximate number, location, depths, completion details and pumping rates of the well components of the preferred system will be determined. In addition, the preliminary design work will evaluate control technology for the pumps and any ancillary systems forming the system infrastructure and connectivity to the deep outfall/water treatment plant.

A report will be prepared that will summarize the results of the field investigations, numerical modelling and preliminary system design.

8.0 TASK 6 – LONG -TERM PUMPING

An optimum pumping rate for the interim system will be determined from work undertaken in tasks 3, 4 and 5. The well(s) will be pumped continuously at this rate, discharging to the deep outfall, until the long-term remedial action is implemented in the south Fan Area.

9.0 ADDITIONAL INFORMATION

9.1 Personnel

The field component of the hydrogeological work will be directed by Mike Dobr (Associate) and reviewed by Don Chorley (Principal), with Willy Zawadzki undertaking the FEFLOW modelling component.

9.2 Meetings

It is anticipated that a technical meeting will be held with Regulator staff and stakeholders during the initial stages of the groundwater program to ensure that any technical concerns held by the Regulator and stakeholders are addressed in the program design and implementation. The Regulator technical staff will be kept appraised of developments during the testing program by both informal advice and in the bi-weekly progress reports issued by the Project manager. A second technical meeting is anticipated with the Regulator and stakeholders at the time of report submission.

9.3 Schedule

The geophysical survey has been completed and the approval for discharge has been obtained from the Regulator in June 2003. The fieldwork component of the pumping test was initiated during the first week of August, and is expected to be finished in about three weeks. Based on the above workplan, the pumping test and analysis program will be completed within approximately two months (Figure 4). The analysis and numerical modelling components will, in part, be conducted in parallel with the fieldwork program, with completion of the modelling component, preliminary system design and reporting being delivered within three weeks of completion of Task 3. The complete program is therefore anticipated to be finished by mid-October, 2003.

9.4 Deliverables

The primary deliverable of the hydrogeological work program will be a combined factual and interpretive report containing a description of the program, test equipment, methods and results, numerical modelling information and discussion, together with evaluation of various system configurations and a recommendation for a long-term system design (if appropriate) and associated costs.

10.0 CLOSURE

This workplan provides the basis to proceed with a long-term pumping test as an extension to the hydrogeological work conducted in 2002 as part of the DSI work program in the Fan Area by URS. The workplan is not a prescriptive document however, as analysis and review of the results obtained during execution of the program may necessitate amendment to the plan such that the primary objective of ascertaining the feasibility of an efficient and cost-effective groundwater capture system can be realized. Any significant departure from the program outlined in the workplan will be communicated with the Regulator.

Should any clarification of components of this plan be required, Mr. Gerry O'Hara, Project Manager, should be contacted in the first instance.

GOLDER ASSOCIATES LTD.

Don Chorley, M.Sc., P.Geo.
Principal, Senior Hydrogeologist

Gerry O'Hara, M.Phil, P.Eng.
Principal, Britannia Remediation Project Manager

DWC/GOH/KF/blm/rja
012-1830

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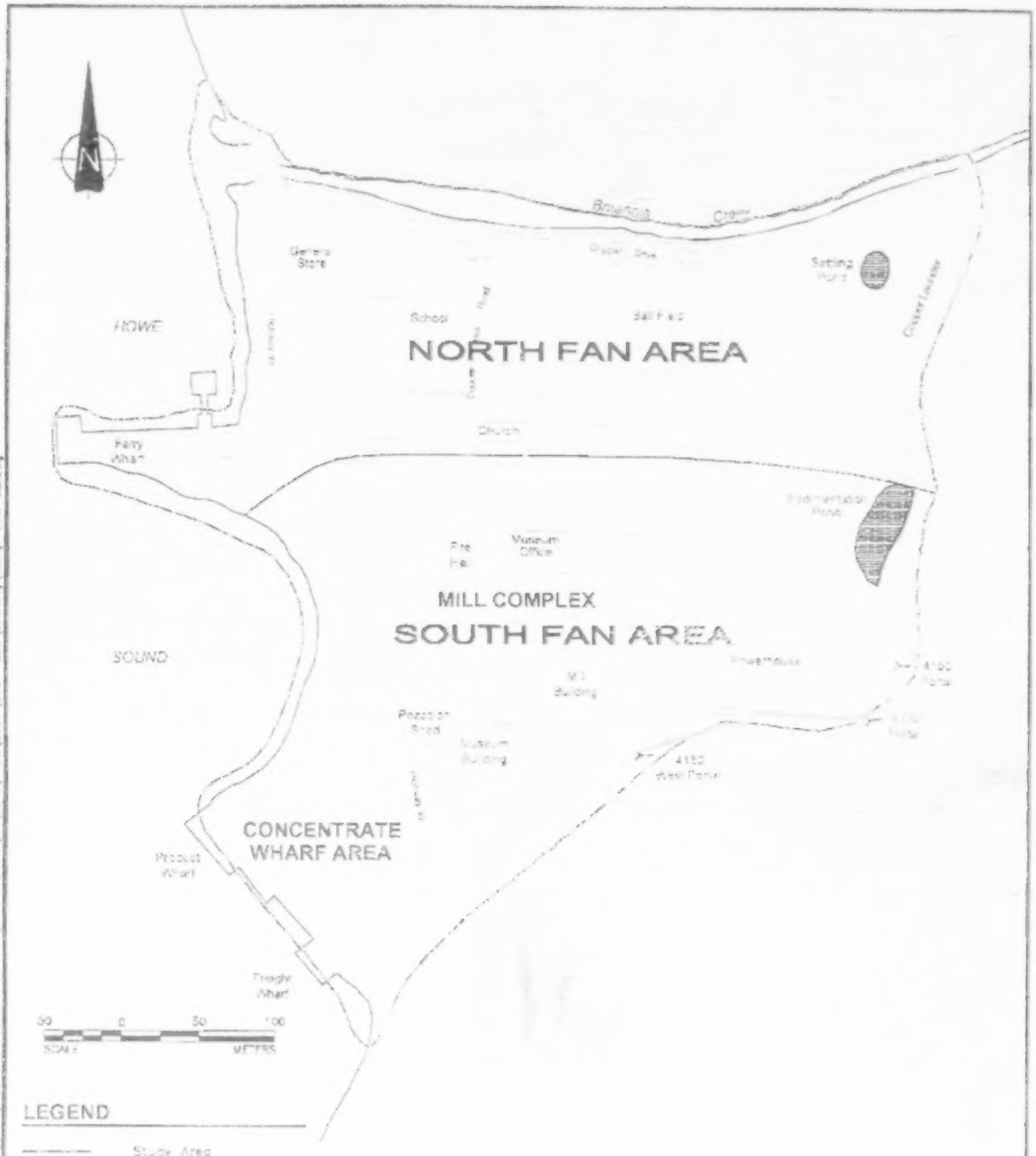


LEGEND

- Study Area
- Existing Buildings
- Roads
- Sediment Ponds

REFERENCES

1) "Fan Area Remediation Planning Document, Britannia Mine Site, B.C." (URS, October 2002).

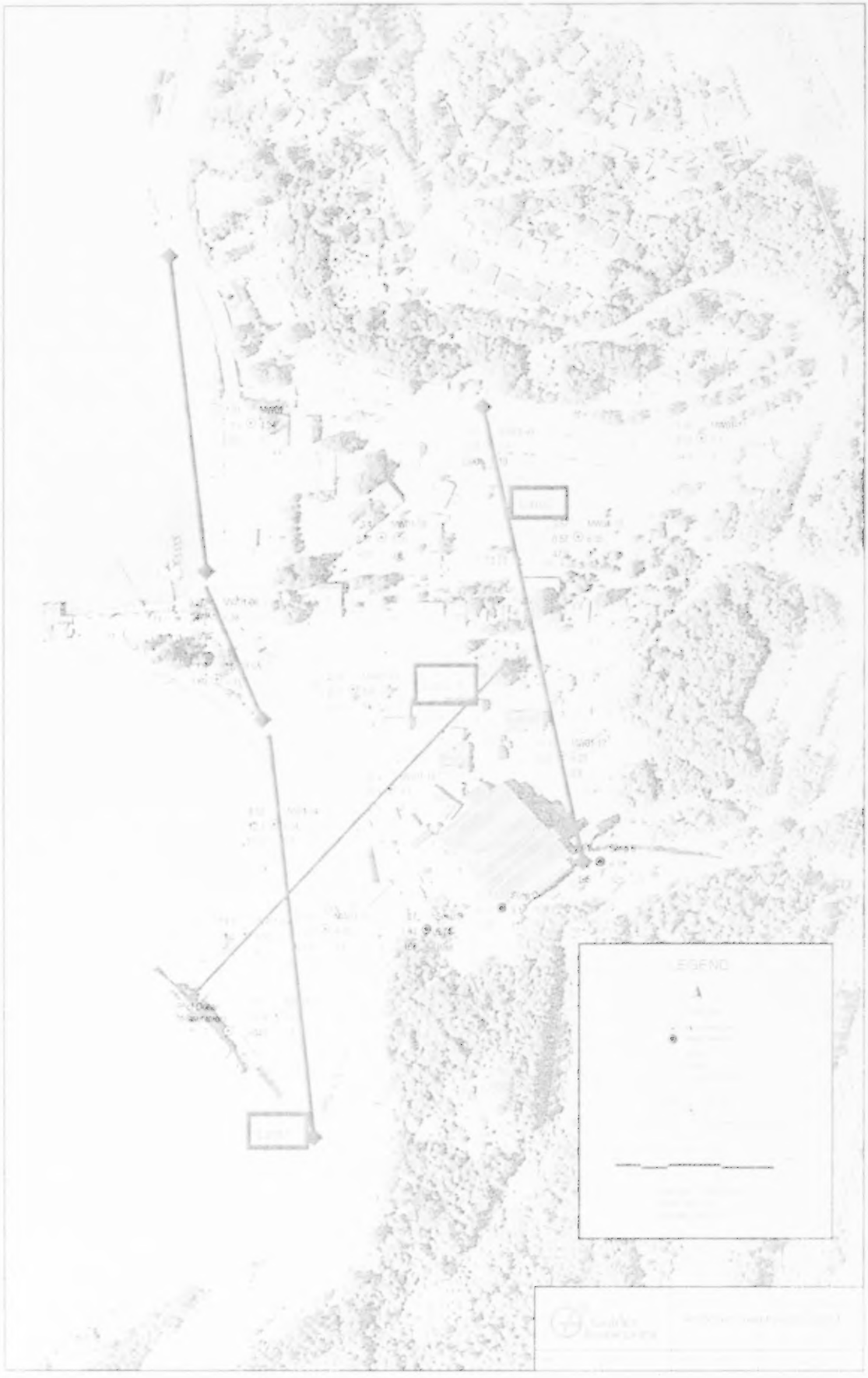
URS

PROJECT	MWLAP REMEDIATION BRITANNIA
TITLE	SITE MAP
PROJECT No.	312-1830
DESIGN	RP 24MAR03
CADD	GD 24MAR03
CHECK	RP 24MAR03
REVIEW	
FILE No.	04830-32
SCALE	AS SHOWN
REV.	

Golder Associates

FIGURE 1

REVISED DATE: 03/05/26 1:3pm By: ggaucz(rynek) CADD FILE N:\Burnaby\Projects\1830\2003\0312-1830\Drawing\mxd\P1F30-02.dwg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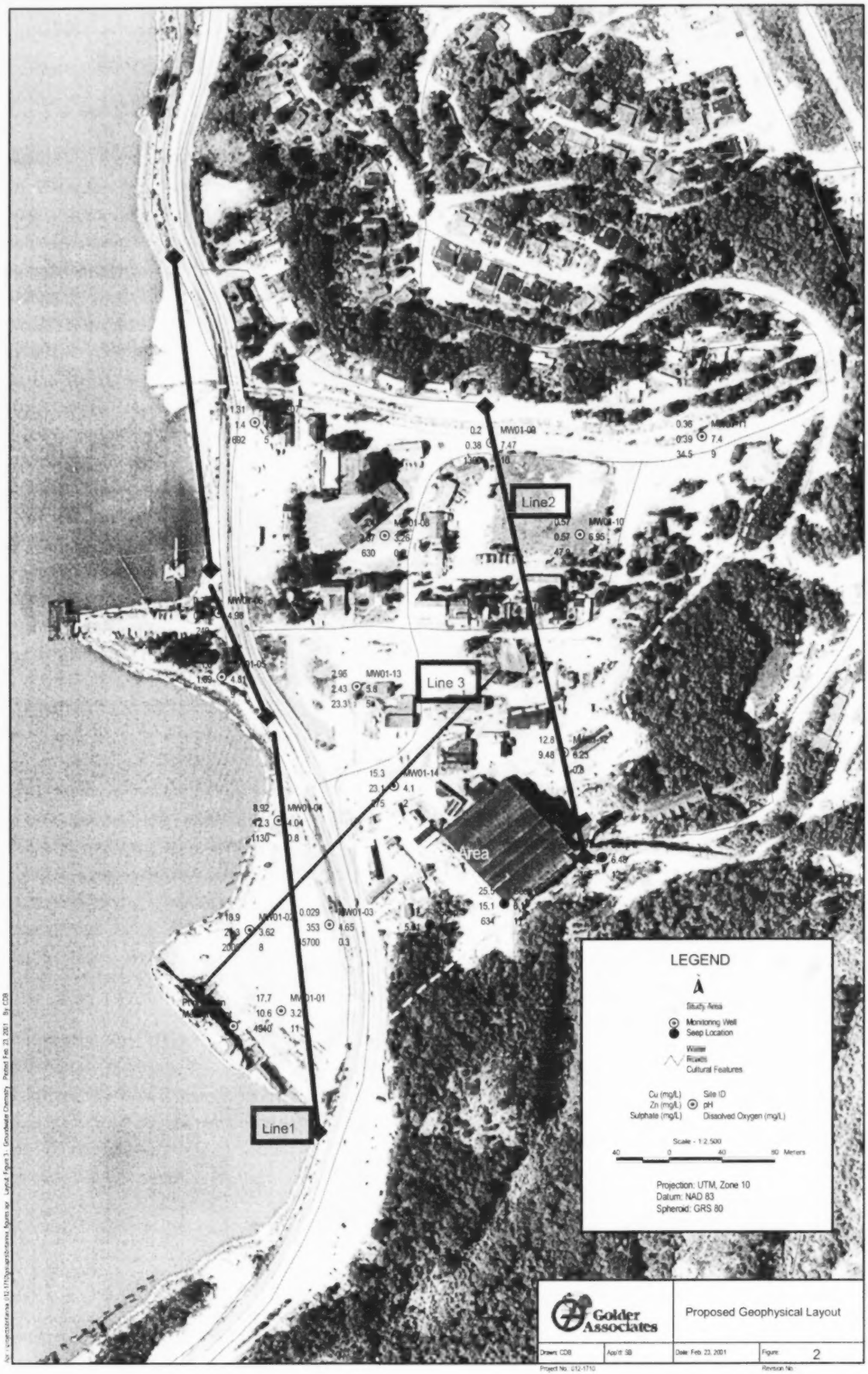
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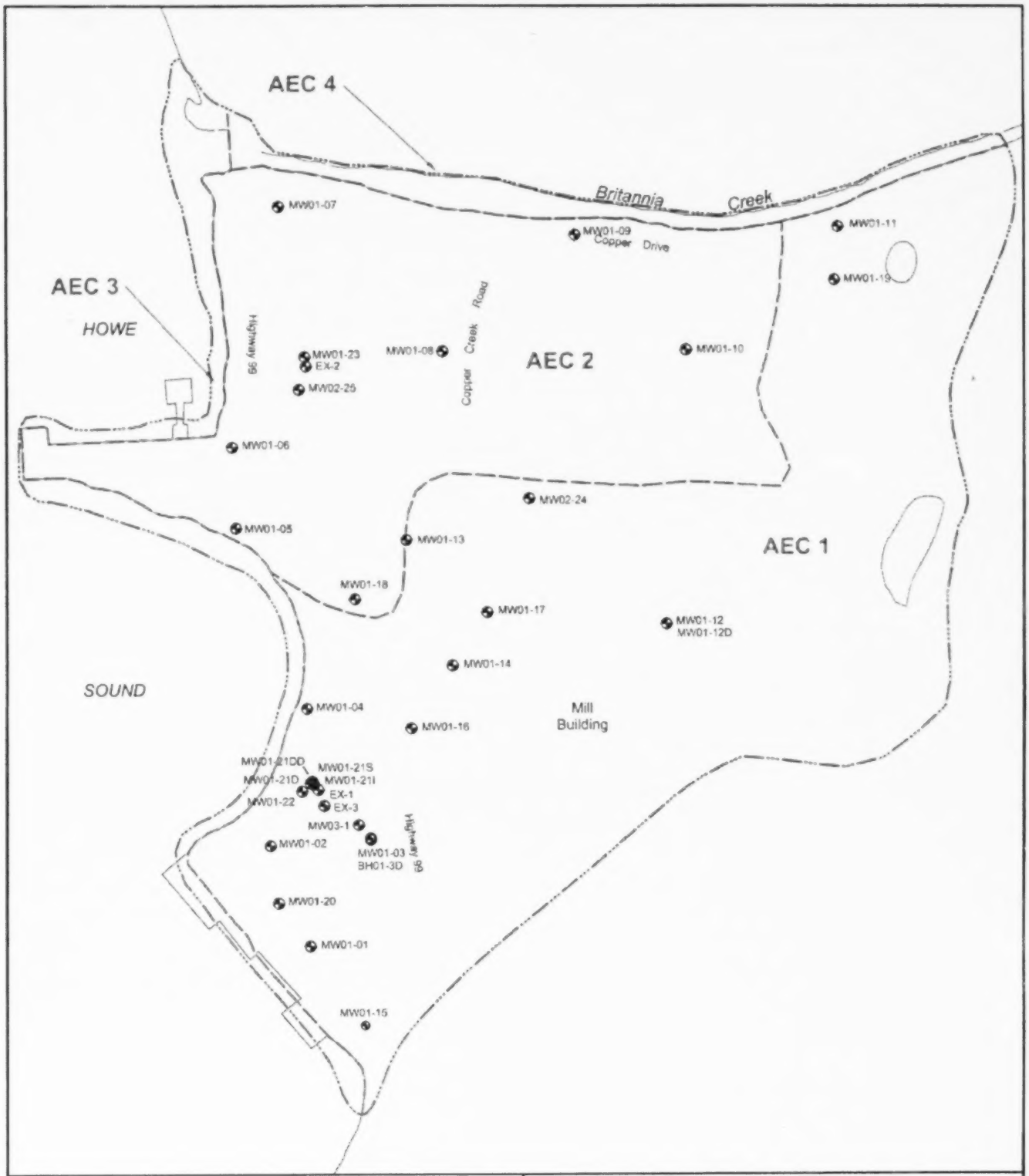
Line2
Line 3
Area
MW01-01
MW01-02
MW01-03
MW01-04
MW01-05
MW01-08
MW01-09
MW01-10
MW01-13
MW01-14
LEGEND
Study Area
Monitoring Well
Seep Location
Water
Roads
Cultural Features
Cu (mg/L)
Zn (mg/L)
Sulphate (mg/L)
Site ID
pH
Dissolved Oxygen (mg/L)
Scale - 1:2,500
40 0 40 80 Meters
Projection: UTM, Zone 10
Datum: NAD 83
Spheroid: GRS 80
Golder Associates
Proposed Geophysical Layout
Drawn: CDB
Appr'd: SB
Date: Feb. 23, 2001
Figure: 2
Project No. 012-1710
Revision No.



LEGEND

Study Area

Existing Buildings

Roads

Sediment Ponds

AEC Boundary

Monitoring Well Location

N W E S

MONITORING WELL LOCATIONS

Britannia Contaminated Sites Investigation - Fan Area DSI
Britannia, British Columbia

BRITISH COLUMBIA MINISTRY OF WATER, LAND AND AIR PROTECTION

URS

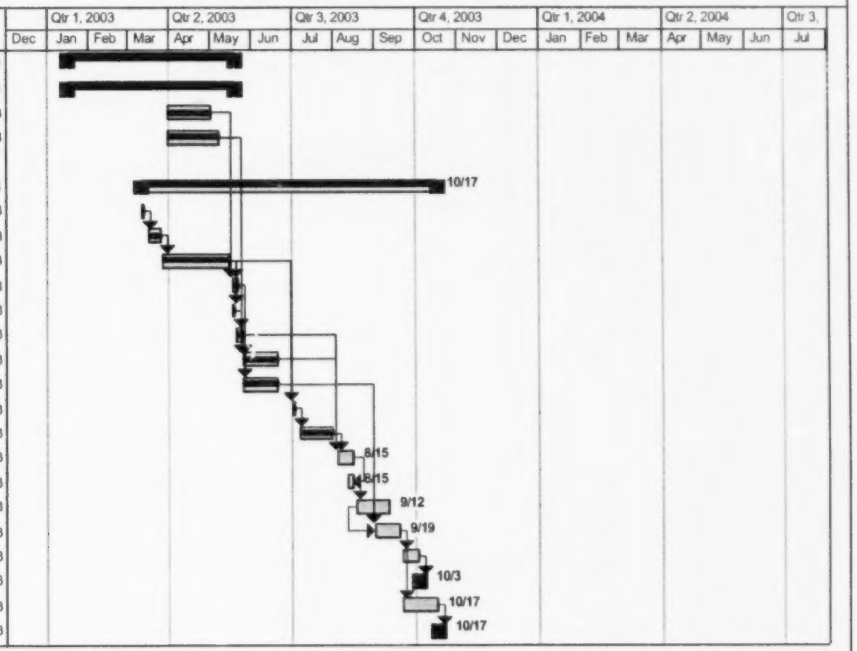
SCALE: 1:3200

0 32 64 96 128 metres

DATE	PROJECT NO	DRAWN BY	REVISION NO	DRAWING NO
May 2002	50319-003	TS	0	FIGURE 3

BRITANNIA MINE REMEDIATION PROJECT - WATER TREATMENT PLANT AND RELATED TASKS

ID	Task Name	Duration	Start	Finish
1	**STAGE 1 REMEDIAL ACTIONS**	**88 days**	**Fri 1/17/03**	**Tue 5/20/03**
2	**Planning Stage 1 Remedial Actions**	**88 days**	**Fri 1/17/03**	**Tue 5/20/03**
14	Obtain Regulatory Approval	25 days	Mon 3/31/03	Fri 5/2/03
15	Obtain Land Access	30 days	Mon 3/31/03	Fri 5/9/03
16				
17	**Groundwater Pumping Test Program**	**158 days**	**Wed 3/12/03**	**Fri 10/17/03**
18	Authorize GW pumping test	3 days	Wed 3/12/03	Fri 3/14/03
19	Initial Planning	8 days	Mon 3/17/03	Wed 3/26/03
20	Finalize Plan & Budget	37 days	Thu 3/27/03	Fri 5/16/03
21	Approval of Plan and Budget	5 days	Mon 5/19/03	Fri 5/23/03
22	Submit discharge application	2 days	Mon 5/19/03	Tue 5/20/03
23	Approve discharge application	5 days	Wed 5/21/03	Tue 5/27/03
24	Discharge pipe engineering	20 days	Mon 5/26/03	Fri 6/20/03
25	Geophysical investigations	20 days	Mon 5/26/03	Fri 6/20/03
26	Review Well Suitability	4 days	Tue 7/1/03	Fri 7/4/03
27	Finalize decisions on pipe system	20 days	Mon 7/7/03	Fri 8/1/03
28	Mobilize pump and install pipe	10 days	Mon 8/4/03	Fri 8/15/03
29	Install & connect well	5 days	Mon 8/11/03	Fri 8/15/03
30	Initial test period	20 days	Mon 8/18/03	Fri 9/12/03
31	GW modeling and analysis	15 days	Mon 9/1/03	Fri 9/19/03
32	Prepare Interim Test Report	10 days	Mon 9/22/03	Fri 10/3/03
33	Issue Test Report	0 days	Fri 10/3/03	Fri 10/3/03
34	GW Control Feasibility Assessment	20 days	Mon 9/22/03	Fri 10/17/03
35	Issue GW Control Assessment	0 days	Fri 10/17/03	Fri 10/17/03



GW PUMPING TEST - schedule REV 1
Summary by Golder Associates
Date: Thu 8/7/03

Task	Rolled Up Task	External Milestone	External Milestone
Task	Rolled Up Split	External Milestone	External Milestone
Split	Rolled Up Milestone	External Milestone	Deadline
Progress	Rolled Up Progress	External Milestone	
Milestone	External Tasks	External Milestone	
Summary	Project Summary	External Milestone	

FIGURE 4